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Annals
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RHIZOPOGON IN NORTH AMERICA

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RHIZOPOGON

Rhizopogon Fries & Nordholm emend. Tulasne, Giorn. Bot. Ital. **2**: 56–63. 1844; Fries & Nordholm, Symb. Gast. **1**: 5. 1817; Fries, Syst. Myc. **2**: 293–294. 1823; Summa Veg. Scand. 435. 1849; Tulasne, Fung. Hypog. 85–91. 1851; DeToni in Sacc. Syll. Fung. **7**: 161–164. 1888; Hesse, Hypog. Deutschl. **1**: 86–94. 1891.—Not Corda, Anleit. z. Stud. Myc. (lxxxiii) 110. *pl. D. 46. f. 16–18.* 1842.—*Hysteromyces* Vittadini, Notiz. nat. e civ. sulla Lombardia **1**: 340. 1844.—*Splanchnomyces* Corda in Sturm, Deutschl. Fl. **3**: 3–4. *pl. 2.* 1831; Anleit. z. Stud. Myc. (lxxxii) 107. *pl. D. 45.* 1842; Icon. Fung. **5**: 26. 1842; *Ibid.* **6**: 37–45. 1854, (in part); Nees v. Esenbeck, Th. F. L. & Henry, A. Syst. d. Pilze **1**: 73. *pl. 10.* 1837.

The type species of the genus is *Rhizopogon luteolus* Fries & Nordholm emend. Tulasne.

Fructifications globose, ellipsoidal and oblately spheroidal to irregular; fibrils filiform, terete or flattened, loosely or innately appressed, simple or anastomosing, leading to rhizomorphs, usually dark-colored when dry; peridium either thick, subcoriaceous, stupose, or thin, submembranaceous, and separable from the gleba with difficulty if at all, context either compact or loosely woven; gleba at first white, becoming

darker; cavities irregular, subequal, at first hollow, then more or less filled with spores; septa homogeneous or scissile, composed of branched interwoven hyphae, often gelatinizing at maturity; basidia varying from ovoid to cylindrical, 2–8-spored; spores ellipsoidal, unicellular, 1–2-guttulate, sometimes appearing 2-celled at maturity, due to the peculiar position the nucleus assumes.

In 1817 Fries and Nordholm described *Rhizopogon luteolus,* and Fries (1823) added three species, one of which proved to be an ascomycete, and the other two, synonyms of *R. luteolus.* Vittadini, Corda, and others treated the genus as ascomycetous, considering *Rhizopogon albus* Fries (1823) as the type. Corda (1831) described *Splanchnomyces,* with *S. roseolus* (see p. 16) as the type, and later added many other species which are to be looked for in various modern genera of the *Hymenogastraceae.* Vittadini, after having *Hysteromyces* in manuscript for several years, published it, with *H. vulgaris* (*Rhizopogon rubescens* var. *Vittadinii* Tulasne) as the type, in the same year (1844) in which Tulasne emended the genus *Rhizopogon* Fries & Nordholm.

Not until a later paper will we attempt a discussion of the relations of *Rhizopogon* to the other genera of the *Hymenogastraceae,* but the taxonomic study of the genus has unearthed a series of forms which anticipate a very interesting morphological development within the genus, should sufficient histological study be possible. We refer here particularly to the simplex and duplex character of the peridium. The outer layer of the duplex forms is sometimes very thin (*R. maculatus*) or often is thick and cracked (*R. pannosus* and *R. Briardi*). Is the thin outer layer of some of the species of *Rhizopogon* comparable to the universal veil or "blematogen" found in the button stage of some of the evolvate agarics and reported by Conard[1] in *Secotium agaricoides?* Or, is the thick, cracked, outer layer of such forms as *R. pannosus* and *R. Briardi* comparable to the volva of certain *Agaricaceae* and *Phallaceae?* These questions can be answered only after

[1] Conard, H. S. The structure and development of Secotium agaricoides. Mycologia **7**: 94–104. *pl. 157.* 1915.

satisfactory study of the development of the fruit-bodies has been made by those to whom fresh material in all stages is accessible.

Although we have had the opportunity to study a few specimens which were put up in alcohol, our descriptions are based on dry herbarium specimens, as is also our key. As a standard for color descriptions we have used Ridgway, 'Color Standards and Nomenclature,' Washington, D. C., 1912. As to the citation of specimens, the data given are those received with the specimens. The location of all specimens is designated by giving in parenthesis the name of the herbarium preceded by "in."

We gratefully acknowledge all who have aided us in the study of herbarium material, making possible this record of species of *Rhizopogon*. We are thus indebted to the Missouri Botanical Garden for the use of library and herbarium facilities; to Dr. E. A. Burt for helpful suggestions and access to his private herbarium; to Dr. LeRoy Abrams for the opportunity to study specimens from the Dudley Herbarium of the Leland Stanford Jr. University; to Prof. G. F. Atkinson for specimens from his herbarium; to Dr. H. M. Fitzpatrick for specimens from the Department of Plant Pathology Herbarium, New York State College of Agriculture at Cornell University; to Dr. N. L. Gardner for access to his own collections of *Rhizopogon;* to Dr. H. D. House for permitting us to study the collections in the New York State Herbarium; to Mr. C. G. Lloyd for access to the extensive collection of *Rhizopogon* in his herbarium; to Dr. W. R. Maxon for sending us specimens from the United States National Herbarium; to Dr. W. A. Murrill for the opportunity to study the unmounted specimens of *Rhizopogon* in the New York Botanical Garden Herbarium; to Mrs. F. W. Patterson for the privilege of studying the specimens in the Pathological Collections, Bureau of Plant Industry, United States Department of Agriculture; and to Dr. J. R. Weir for specimens from Idaho.

Key to North American Species

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1. Peridium simplex 4
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2. Peridium thick (more than 200 μ) 3
3. Outer layer sloughing off, giving a mottled appearance, greenish ..... *R. viridis* (p. 5)
3. Outer layer sloughing off, leaving large patches, reddish brown ..... *R. pannosus* (p. 6)
3. Outer layer not as above ..... *R. diplophloeus* (p. 8)
4. Peridium thick (540–600 μ), outer portion of hyphae with vesicular cells ..... *R. pachyphloeus* (p. 9)
4. Peridium much thinner 5
5. Fibrils abundant 6
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7. Peridium 400–600 μ thick, fibrils becoming free and prominent below ..... *R. provincialis* (p. 13)
7. Peridium 240–440 μ thick, fibrils not as above ..... *R. luteolus* (p. 10)
8. Septa thick (120–160 μ), fibrils white or dirty gray ..... *R. graveolens* (p. 15)
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9. Basidia subglobose, greatly gelatinized ..... *R. roseolus* (p. 16)
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10. Peridium thin (60–200 μ), septa less than 25 μ thick ..... *R. induratus* (p. 17)
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11. Peridium thin (160–220 μ), spores 5–10×3–4 μ ..... *R. rubescens* (p. 18)
11. Peridium thicker (260–400 μ), spores 6–8×3 μ ..... *R. rubescens* var. *Vittadinii* (p. 20)

1. **Rhizopogon maculatus** Zeller & Dodge, sp. nov.

Fructificationes subglobosae vel olivaeformes, 1–2 cm. diametro metiens, post siccandum maxime contractae, "pale grayish vinaceous" vel "vinaceous-brown" (Ridgway), siccatae saturatiores, sordide albidis cum maculis, ubi peridi stratum exterum manet; funiculi pauci, prominentes, inferne radiciformes, innati-applicati in parietibus, superne evanescentes, "vinaceous-brown" (Ridgway), vel saturatiores; peridium tenue, 20–60 μ crassitudine, duplex, stratum exterum hyphis hyalinis implexum, qui facile a strato intero divelli potest; stratum interum saturatius, "ochre-red" (Ridgway), compactum, dimidia exteri crassitudine; gleba recens albida, grisea et ossea siccata; locelli angusti, irregulares, vacui; septa 40 μ crassitudine, hyalina, hyphis gelatinosis compacta, non scissilia; basidia inconspicua, hyalina, tetraspora, sterigmatibus circa 3 μ longitudine; sporae acrogenae, subfusiformes, hyalinae, leves, 2-guttulatae, 7–10×3–4 μ.

Habitat in terra arenosa in pinetis. California. Veri.

Type: in Zeller Herb. and Dodge Herb.

Fructifications subglobose to olive-shaped, 1–2 cm. in diameter, shrinking to almost nothing on drying, color pale grayish vinaceous to vinaceous-brown, drying to dark vinaceous-brown, mottled with dirty white patches due to the partial sloughing off of the outer peridial layer; fibrils few and conspicuous, rhizomorph-like below to innate-appressed over the sides, disappearing above, vinaceous-brown or darker; peridium thin, 20–60 μ thick, duplex, the outer layer of loosely interwoven, hyaline hyphae, easily separable from the inner layer, which is darker, ochre-red, compact, about one-half the thickness of the outer layer; gleba white when fresh to grayish and bony hard when dry; cavities narrow and irregular, empty; septa average about 40 μ thick, hyaline, made up of much gelatinized hyphae, not scissile; basidia inconspicuous, mostly 4-spored; sterigmata about 3 μ long; spores acrogenous, hyaline, subfusiform, 7–10$\times$3–4 μ, 2-guttulate, smooth.

In sand under conifers. California. Spring.

R. maculatus is like *R. Briardi* and *R. pannosus* in that the peridium is duplex and the outer layer is partially sloughed off in patches, and it is also closely allied to *R. diplophloeus* and *R. angustisepta* in that it has a duplex peridium.

Specimens examined:

California: San Francisco, *N. L. Gardner*, type (in Zeller Herb., 1382, and Dodge Herb., 834).

2. **Rhizopogon viridis** Zeller & Dodge, sp. nov.[1]

Fructificationes oblatae-sphaeroideae, 1$\times$2 cm. metiens, post siccandum non contractae, "citrine-drab" vel "olivaceous black(1)" (Ridgway), siccatae saturatiores, superficie maculata, superne squarrosa; funiculi pauci, innati-applicati, non prominentes, nigri; peridium crassum, 300–500 μ crassitudine, duplex, stratum exterum 100–200 μ crassitudine, "Vandyke brown" (Ridgway) sub lente, hyphis magnis septatis laxe complexum; stratum interum stuposum, 200–300 μ crassitudine, "Sayal brown" (Ridgway); gleba servata "olive" vel "deep olive" (Ridgway), siccata saturatior; locelli subglobosi vel irregulares, vacui; septa 30–35 μ crassitudine inter hyme-

[1] The specimens of *Rhizopogon viridis* came to us after the paper was in press and thus too late to insert drawings.

nia, hyalina, hyphis magnis, gelatinosis, laxe contexta, non scissilia; basidia conspicua, oblonga, hyalina, parietibus gelatinosis, 9–16×6.5–8 μ, mono- vel tetraspora, sterigmatibus brevibus; sporae acrogenae, olivaceae acervatae, singulatim hyalinae, ellipsoideae, leves, saepe diguttulatae, 5–8×2–3 μ.

Habitat sub foliis in pinetis. Idaho. Autumno.

Type: in Weir Herb., Zeller Herb., and Dodge Herb.

Fructifications oblate-spheroidal, 1×2 cm., not shrinking on drying, citrine-drab to olivaceous black(1) when fresh, drying darker, surface somewhat mottled due to the partial sloughing off of the darker outer layer, the darker places squarrose; fibrils scanty, innate-appressed, inconspicuous, black; peridium thick, 300–500 μ, duplex, the outer layer 100–200 μ, Vandyke brown under the microscope, composed of large, loosely woven, septate hyphae, the inner layer stupose, 200–300 μ thick, Sayal brown under the microscope; gleba olive to deep olive in preserved material, drying to dark olive; cavities subglobose to irregular, empty; septa 30–35 μ, hyaline, composed of large, loosely woven, gelatinized hyphae, not scissile; basidia conspicuous, oblong, hyaline, with gelatinized walls, 9–16×6.5–8 μ, 1–4-spored; sterigmata short; spores acrogenous, olive in mass, appearing hyaline when alone, ellipsoidal, 5–8×2–3 μ, often 2-guttulate.

In pine leaf mould. Idaho. September to October.

Rhizopogon viridis presents a mottled appearance of the fructifications, as does *R. maculatus,* but the colors of the two species are distinct and the lighter spots on *R. viridis* are due to the inner peridial layer, while in *R. maculatus* they are due to the outer layer. The hyphae of the outer peridial layer have a suggestion of the condition to be found in *R. diplophloeus.*

Specimens examined:

Idaho: Priest River, *J. R. Weir,* type (in Weir Herb., Zeller Herb., 1447, and Dodge Herb., 849).

3. **Rhizopogon pannosus** Zeller & Dodge, sp. nov.

Fructificationes caespitosae, subpiriformae vel subglobosae, et irregulares, 1.5–3 cm. diametro metiens, "russet-vinaceous" vel "sorghum-brown" et "light seal-brown" (Ridgway) ubi tactae, pannis "sorghum-brown" (Ridgway) relictis cum hoc stratum ruptum est;

funiculi inconspicui, superne fere desunt, aut innati-applicati sunt, inferne breves sed magni, leves, fere politi, "light seal-brown" (Ridgway); peridium crassum, 440–1000 μ, duplex, strato extero facile ab intero separante, pannis relictis, 200–500 μ crassitudine, hyphis laxe implexis, "vinaceous-russet" (Ridgway) sub lente, strato intero 240–600 μ crassitudine, compactiore dilutioreque extero, hyphis granulosis contexto, "Corinthian red" (Ridgway) extus, vel cremeo intus; gleba "light buff" (Ridgway) siccata, coriacea; locelli subglobosi vel irregulares, vacui; septa 100 μ crassitudine, hyalina, hyphis septatis laxe implexis, subscissilia; basidia hyalina, 7–8×16 μ, mono- vel pluri-sporifera, oblonga, sterigmatibus 3–5 μ longitudine; sporae acrogenae, hyalinae vel cremeae acervatae, ellipsoideae, 7–9×3–5 μ, 1–2-guttulatae, leves.

Habitat in viis. America occidentale. Aestate.

Type: in Zeller Herb. and in Dodge Herb.

Fructifications cespitose, subpyriform to depressed globose and irregular, 1.5–3 cm. in diameter, from russet-vinaceous to sorghum-brown and light seal-brown where bruised, the sorghum-brown patches of the outer peridial layer being isolated as this layer cracks; fibrils inconspicuous, almost entirely wanting above to innate-appressed below, where they are short but large, appearing as large, smooth, almost shiny ridges, light seal-brown; peridium thick, 440–1000 μ, duplex, thick sections more or less claret-brown under the microscope, the outer layer easily separable from the inner, sloughing off, leaving patches 200–500 μ thick, of loosely woven hyphae, vinaceous-russet under the microscope, inner layer 240–600 μ thick, more compact and lighter than the outer layer, made up of granular hyphae, from Corinthian red in the outer part to creamy within; gleba light buff when dry, coriaceous; cavities averaging 5–6 per mm., subglobose to irregular, empty; septa average about 100 μ broad, hyaline, composed of loosely woven, septate hyphae, more or less scissile; basidia hyaline, 7–8×16 μ, 1–several-spored, oblong; sterigmata one-half as long as spores; spores acrogenous, hyaline to cream-colored in mass, ellipsoid, 7–9×3–5 μ, 1–2-guttulate, smooth.

In trampled roadways. Pacific Coast. Early summer.

R. pannosus, although quite closely related to *R. Briardi,* is a distinct species. The isolated patches of the outer peridial layer are much more conspicuous than in *R. Briardi*

and the colors of the two are distinct. The septa of *R. Briardi* are composed of a pseudo-parenchymatous tissue, while in *R. pannosus* the hyphae are loosely woven and the septa are somewhat scissile and about twice as broad as in *R. Briardi.*

Specimens examined:

Washington: Klickitat Co., Falcon Valley, *W. N. Suksdorf, 629, 1029* (in Lloyd Mus., 5603 and 11443, respectively).

California: Mariposa Co., *W. A. Setchell,* type (in Zeller Herb., 1380, and in Dodge Herb., 835).

4. **Rhizopogon diplophloeus** Zeller & Dodge, sp. nov.

Fructificationes globosae vel irregulares, diametro 1–2.5 cm. metiens, argillaceae recens lectae, tactu brunnescentes, demum "Verona brown" (Ridgway) et nigrescentes siccatae; funiculi pauci radicantes, innati-applicati, nigri; peridium crassum, duplex, stratum exterum 140–180 μ crassitudine, hyphis bulbosis, sub lente fulvis, laxe complexum; stratum interum 260–300 μ crassitudine, hyphis melleis dense compactum; gleba "Isabella-color" (Ridgway) fulvescens, siccata ossea, nigrescens; locelli globosi, irregulariusculi, recens vacui, maturitate sporis repleti; septa 30–40 μ crassitudine, hyphis subhyalinis compacta, non scissilia; basidia clavata, 25–30 $\times$12–18 μ, hyalina, di- vel octospora, vulgo octospora, sterigmatibus 6–10 μ longitudine; sporae acrogenae, ellipsoideae, dilute cremeae sub lente, leves, 5.3–7$\times$2–3.5 μ, diguttulatae.

Habitat inter rhizoma *Adianti pedati* in lateribus rupium. Washington. Aestate.

Type: in Zeller Herb., Dodge Herb., and Mo. Bot. Gard. Herb.

Fructifications globose to irregular, 1–2.5 cm. in diameter, "clay colored" when fresh, becoming darker when bruised, Verona brown to nearly black when dry; fibrils scanty, innate-appressed, black when dry, leading to rhizomorphs; peridium 400–480 μ thick, duplex, the outer layer dark tawny under the microscope, about 140–180 μ thick, composed of irregularly swollen hyphae, loosely interwoven, the inner layer honey-colored, about 260–300 μ thick, composed of closely woven hyphae; gleba from Isabella-color to brown or almost black on drying, bony hard when dry; cavities subglobose to somewhat irregular, empty when young, filled with spores at maturity; septa 30–40 μ thick, composed of compact, subhyaline hyphae, not scissile; basidia clavate, 25–30$\times$12–18 μ,

hyaline, 2–8-spored (mostly 8-spored); sterigmata 6–10 μ long; spores acrogenous, dilute cream-colored under the microscope, ellipsoid, 5.3–7×2–3.5 μ, smooth, often 2-guttulate.

Clinging to sides of an overhanging rocky cliff among rhizomes of *Adiantum pedatum*. Washington. Summer.

Specimens examined:

Washington: Friday Harbor, *S. M. Zeller, 1360*, type (in Zeller Herb., 1360, Dodge Herb., 823, and Mo. Bot. Gard. Herb., 54977); Bingen, *W. N. Suksdorf, 811* (in Lloyd Mus., 7300).

5. **Rhizopogon pachyphloeus** Zeller & Dodge, sp. nov.

Fructificationes ovoideae, 2.5–3 cm. in diametro metiens, post siccandum compactae, recens ochraceae vel isabellinae (Murrilli memoranda), "Brussels-brown" vel "bay" (Ridgway) vel saturatius; odor foetidus, non late penetrans (Murrillo teste); funiculi prominentes, tenues, innati-applicati, ramosissimi, etiam reticulati, totam fructificationem in reticulo circumcludentes, fusci, peridio saturatiores, purpurescentes semitranslucentesque; peridium 540–600 μ crassitudine, simplex, compactum, hyphis irregularibus vesiculosis contextum, gelatinosis, "yellow-ochre" (Ridgway) sub lente; gleba umbrina, albidis cum maculis recens conspersa, siccando nigrescens, recens mollis et gelatinosa, sed sicca dura, nitensque ubi caesa; locelli subglobosi vel irregulares, sporis impleta, circa 120 μ latitudine; septa 40 μ crassitudine, hyalina, hyphis gelatinosis contexta, non scissilia; basidia prominentia, hyalina, gelatinosa, 6–8×11–13 μ, piriformia, sterigmatibus brevibus; sporae umbrinae, acrogenae, cremeae sub lente, ellipsoideae, rare allantoideae, 1–2-guttulatae, leves, nucleo longo media in cellula locato, 3–5×5–10 μ.

Habitat in terra inter lichenes. Ubique. Hieme.

Type: in N. Y. Bot. Gard. Herb.

Fructifications ovoid, 2.5–3 cm. in diameter, perceptibly shrinking on drying, "ochraceous to isabelline" (Murrill) when fresh, drying to Brussels-brown or even bay and darker; odor "foul but not very 'spreading'" (Murrill); fibrils prominent, slender, innate-appressed, much branched and reticulated, enclosing the whole fructification in a net, brownish when drying, darker than the peridium, color "red-amber," semi-translucent; peridium thick, 540–600 μ, simplex, compact, of interwoven, irregularly vesiculose, gelatinized, large hyphae, yellow-ochre under the microscope; gleba

umbrinous, mottled with white when fresh, drying almost black, cut surface shiny, hard when dry, but soft-gelatinous when fresh; cavities subglobose to irregular, filled with spores, about 120 μ broad; septa about 40 μ broad, hyaline, of very gelatinized hyphae, not scissile; basidia quite prominent, hyaline, gelatinized, 6–8×11–13 μ, pyriform; sterigmata short; spores raw umber in mass, acrogenous, creamy, ellipsoid, sometimes somewhat allantoid, 1–2-guttulate, smooth, nucleus long, equatorially placed, 3–5×5–10 μ.

On bank among lichens. Cosmopolitan. December to January.

This species seems to be closely related to the forms having duplex peridia through *R. diplophloeus*, in that both have vesicular cells in the hyphae of the outer portion of the peridium. In external appearance it resembles *R. luteolus*, while the greatly gelatinized basidia relate it to *R. roseolus*.

Specimens examined:

Exsiccati: Rabenhorst-Winter, Fung. Eur., 3436, under the name *Melanogaster Owanianus* Kalchbr. in herb.

Africa: Cape Good Hope, near East Somerset, *P. MacOwan*, in Rabenhorst-Winter, Fung. Eur., 3436 (in Mo. Bot. Gard. Herb., 5646).

Jamaica: Cinchona, *W. A. & E. L. Murrill, 605*, type (in N. Y. Bot. Gard. Herb.).

Colorado: Fort Collins, *B. O. Longyear* (in Lloyd Mus., 12556).

Australia: Sydney, *R. T. Baker* (in Lloyd Mus., 03957).

6. **Rhizopogon luteolus** Fries & Nordholm emend. Tulasne, Giorn. Bot. Ital. **2**: 57. 1844; Fries & Nordholm, Symb. Gast. **1**: 5. 1817; Fries, Syst. Myc. **2**: 294. 1823; Summa Veg. Scand. 435. 1849; Wahlenberg, Fl. Suec. **2**: 997. 1826; Rabenhorst, Fl. Lusatica, Abt. II. 388. 1840; Deutschl. Krypt. Fl. **1**: 246. 1844; Desmazières, Pl. Crypt. Exsicc., ed. 2, 21. No. 1013. 1846; Tulasne, Fung. Hypog. 87–88. 1851; DeToni in Sacc. Syll. Fung. **7**: 161. 1888; Hesse, Hypog. Deutschl. **1**: 87–89. 1891.—Not Krombholz, Nat. Abbild. u. Beschr. Schwämme **8**: 21. *pl. 60, f. 13–15*. 1843; nor Karsten, Finska

Vet.-Soc. Bidrag Natur och Folk **25** : 354. 1876. (Myc. Fenn. **3** : 354. 1876).

Splanchnomyces luteolus Corda, Icones Fung. **6** : 38. *pl. 7. f. 69.* 1854.—*Splanchnomyces Rabenhorstii* Corda, *Ibid.* **6** : 39–40. *pl. 8. f. 73.* 1854.—*Splanchnomyces Cauvinianus* Corda, *Ibid.* **6** : 39. *pl. 8. f. 72.* 1854.—*Hysterangium Duriaeanum* Tulasne, Actes Soc. Linn. de Bordeaux **13** : 263. 1844.

Illustrations: Hesse, Hypog. Deutschl. **1** : *pl. 2. f. 1–4, pl. 5. f. 5–7, pl. 9. f. 26;* Tulasne, Fung. Hypog. *pl. 1. f. 5, pl. 11. f. 5.*

Type: location unknown, but a specimen from Lloyd which we have studied is from the type locality.

Fructifications subglobose to oblong and often pear-shaped, diameter up to 3 cm. when dry, color warm buff to mummy-brown when dry; odor weak at first and later stercoreous (Tulasne); fibrils numerous but not prominent, fine, elastic, about the same color as the peridium or darker, composed of septate hyphae, innate-appressed above and not very prominent below; peridium thick, 240–400 μ, simplex, context meshy and quite loose, stupose, ochraceous-buff to ochraceous-tawny under the microscope; gleba white at first, then yellowish when dry; cavities narrowly labyrinthiform, empty or filled with spores where the cavities are small; septa narrow, 30–60 μ, made up of hyaline, branched hyphae mostly extending parallel with the surface of the hymenium, becoming scissile early; basidia clavate, 12–13×9–10 μ, hyaline; sterigmata as long as the spores; spores acrogenous, distinctly colored, ochraceous-tawny, ellipsoidal, 7–16×3–5 μ, smooth.

In sandy coniferous woods. Cosmopolitan.

Jamaica material collected by F. S. Earle, 358, does not agree in all characters with the other *R. luteolus* material. This form has a thinner peridium and less numerous fibrils than in other specimens. No field notes accompany this collection. The colors when fresh are characters which are very desirable in the separation of species like *R. rubescens* and *R. luteolus.*

Specimens examined:

Exsiccati: von Höhnel, Krypt. Exsicc., 1607; Klotzsch, Herb. Myc., ed. 2, by Rabenhorst, **4**: 320. 1856; Rabenhorst, Crypt.-Samml. f. Schule u. Haus **1**: *pl. 13;* Ravenel, Fung. Car. **1**: 75, under the name *Rhizopogon rubescens;* Schroeter, Pilze Schles., 1685; Sydow, Mycoth. Germ., 1060; *Ibid.*, 1061, 1062, under the name *Rhizopogon provincialis;* Westendorp & Wallays, Herb. Crypt. Belg. **1**: 39.

Norway: Ekerö, *L. Romell* (in Burt Herb.).

Sweden: Upsala, *C. G. Lloyd, 1908* (in Lloyd Mus., 08559).

Germany: *L. Rabenhorst,* Crypt.-Samml. f. Schule u. Haus **1**: *pl. 13* (in Mo. Bot. Gard. Herb.); *Klotzsch,* Herb. Myc., ed. 2, by Rabenhorst, **4**: 320 (in Mo. Bot. Gard. Herb.); *P. Hennings,* under the name *Rhizopogon virens* (in Ellis Coll., N. Y. Bot. Gard. Herb.); East Prussia, Tilsit, *W. Krüger, 2* (in Lloyd Mus., 6693); Silesia, Falkenberg, *J. Schroeter,* Pilze Schles., 1685 (in Lloyd Mus., 1685); Pomerania, Gutsdorf bei Callies, *P. Sydow,* Mycoth. Germ., 1062 (in Mo. Bot. Gard. Herb.); Brandenburg, Sophienstadt bei Biesenthal, *P. Sydow,* Mycoth. Germ., 1060 (in Mo. Bot. Gard. Herb.), Berlin, *P. Magnus* (in Cornell Univ. Herb.), Berlin 'bei Westend,' *P. Magnus* (in Mo. Bot. Gard. Herb., 55099), Triglitz i. d. Prignitz, *O. Jaap, 13* (in Lloyd Mus., 03905); Westphalia, *P. Magnus* (in Lloyd Mus.).

Austria: Tyrol, Jenesien bei Bozen, *F. von Höhnel,* Krypt. Exsicc., 1607 (in U. S. Nat. Herb.).

Belgium: Flanders, *G. D. Westendorp & A. C. F. Wallays,* Herb. Crypt. Belg. **1**: 39 (in Mo. Bot. Gard. Herb.).

France: Barbison, *C. G. Lloyd* (in Lloyd Mus., 06373).

South Africa: Stellenbosch, *A. V. Duthie* (in Lloyd Mus., 77).

Massachusetts: South Yarmouth, *S. Davis* (in Lloyd Mus., 5895).

New York: West Port, *C. H. Peck* (in Coll. N. Y. State); Ithaca, *D. Reddick* (in N. Y. State Coll. Agr. at Cornell Univ., Dept. Pl. Path. Herb., 7359).

Carolina: *H. W. Ravenel,* Fung. Car. **1**: 75 (in Mo. Bot. Gard. Herb.).

Jamaica: Cinchona, *F. S. Earle, 358* (in N. Y. Bot. Gard. Herb.).

Colorado: Fort Collins, *B. O. Longyear* (in Lloyd Mus., 12161).

Australia: Sydney, *R. T. Baker* (in Lloyd Mus., 03967).

7. Rhizopogon provincialis Tulasne, Fung. Hypog. 88. 1851.

Type: location of authentic material unknown to us.

Fructifications mostly globose to slightly irregular, 1–4.5 cm. in diameter when dry, color when fresh "yellowish white" (Tulasne), when dry Sayal brown to bister, squamulose on top; fibrils innate-appressed and scanty above, becoming prominent and almost free below, dark mummy-brown when dry; peridium thick, 400–600 μ, simplex, light orange-yellow under the microscope, composed of closely woven, small, almost hair-like, branched hyphae with blunt tips; gleba from "white to a light greenish yellow" (Tulasne) when fresh, tawny olive when dry, moderately hard; cavities subglobose to somewhat irregular, larger toward the center, the larger empty; septa 50–80 μ broad, comparatively narrow, composed of subhyaline, loosely woven hyphae, scissile; basidia clavate, 15–16$\times$7–7.5 μ, hyaline, 2–6-spored; sterigmata about as long as the spores; spores acrogenous, in mass raw sienna, under the microscope dilute yellow, ellipsoid, 6–7$\times$3–4 μ, smooth, 1–2-guttulate.

In sandy soils in mixed woods. Gardner's collection was reported under leaves of *Pinus* and *Eucalyptus*. Central Europe, California, and New Zealand. November to February.

Specimens examined:

Exsiccati: Roumeguère, Fung. Gall. Exsicc., 3825.

England: Hampshire, New Forest, *G. E. Massee,* (?) (in Mo. Bot. Gard. Herb., 5641).

France: Nice, *J. L. E. Boudier* (in Lloyd Mus., 5344); *Robert* (in Lloyd Mus., 07109); *C. Roumeguère,* Fung. Gall. Exsicc., 3825 (in Mo. Bot. Gard. Herb., 5639).

Washington: *W. N. Suksdorf, 814* (in Lloyd Mus., 7295).

California: San Francisco, *N. L. Gardner, 208* (in Zeller Herb., 1378, and Dodge Herb., 836).

New Zealand: Christchurch, *G. Brown* (in Lloyd Mus., 11476).

8. Rhizopogon occidentalis Zeller & Dodge, sp. nov.

Fructificationes piriformes vel irregulares, 1–4 cm. diametro metiens, citrinae recens lectae, odor massae male fermentatae (Hendersonis memoranda), "light buff" vel "mummy-brown" (Ridgway) siccatae; funiculi superne innati-applicati, prominescentes et liberi inferne, tensi et peridium constringentes, "Hessian brown" (Ridgway); peridium tenue, 60–240 μ crassitudine, simplex, byssoideum, hyphis tenuibus contextum, sub lente cremeum vel "buckthorn-brown" (Ridgway); gleba siccata, "pale yellow-orange" vel "Sudan brown" (Ridgway), fragilis; locelli globosi aut irregulares, vacui; septa circa 20–60 μ crassitudine, hyphis hyalinis contexta, scissilia; basidia late clavatae, 14×4 μ, hyalina, sterigmatibus brevibus; sporae acrogenae, ellipsoideae, cremeae, 7–9×3–5 μ, leves.

Habitat in terra arenoso in pinetis. America occidentalis. Veri.

Type: in Coll. N. Y. State.

Fructifications pyriform to irregular, 1–4 cm. in diameter when dry, color lemon-yellow when fresh (Henderson's field notes), drying light buff to mummy-brown; odor like sour dough or soured bread (Henderson); fibrils prominent, innate-appressed at the extreme summit, more prominent below and becoming free in the dried specimens, often stretched, constricting the peridium, color Hessian brown; peridium thin, 60–240 μ, simplex, context cottony, made up of fine hyphae, cream-colored to buckthorn-brown under the microscope; gleba pale yellow-orange to Sudan brown when dry, brittle; cavities globose to irregular, empty; septa about 20–60 μ broad, made up of hyaline hyphae, scissile; basidia broadly clavate, 14×4 μ, hyaline; sterigmata short; spores acrogenous, cream-colored, ellipsoidal, 7–9×3–5 μ, smooth.

In sand under conifers. Western United States. Early spring.

This species differs from *R. luteolus* in larger size, lighter color, more prominent and darker-colored fibrils, in much thinner peridium, softer context, more globose cavities, more cylindric basidia, shorter sterigmata, and lighter-colored, smaller spores.

Specimens examined:

Idaho: Moscow, *L. F. Henderson, 5168,* type (in Coll. N. Y. State).

Washington: Klickitat Co., Bingen, *W. N. Suksdorf, 630, 634, 654, 655, 656, 657, 658, 659, 662, 808, 810, 812, 813, 1004, 1030, 1031, 1035, 1039* (in Lloyd Mus., 5598, 5927, 6115, 6121, 6117, 6118, 6116, 6120, 6119, 7297, 7299, 7294, 7298, 05738, 11441, 11440, 11444, 11442, respectively, in part under the name *Rhizopogon albidus*), also *W. N. Suksdorf* (in Lloyd Mus., 7293).

Oregon: on Columbia River between Hood River and Mosier, *W. N. Suksdorf, 660* (in Lloyd Mus., 039).

California: Pacific Grove, *M. L. Sutliff* (in Coll. N. Y. State and Lloyd Mus., 05260); *W. R. Dudley, 5325* (in Coll. N. Y. State); San Francisco, *N. L. Gardner* (in Zeller Herb., 1381, and Dodge Herb., 838).

9. Rhizopogon graveolens (Vittadini) Tulasne, Fung. Hypog. 88. 1851; DeToni in Sacc. Syll. Fung. **7**: 162. 1888.

Hysteromyces graveolens Vittadini, Notiz. nat. e civ. sulla Lombardia **1**: 341. 1844.

Type: existence of type unknown to us.

Fructifications oblate-spheroidal to subpyriform, 1.5–4 cm. in diameter when dry, color pinkish buff to Sayal brown when dry; odor fetid (Vittadini); fibrils scanty, short, leading from base, innate-appressed, light-colored; peridium thin, 160–240 μ thick, compact, tawny under the microscope; gleba warm buff when dry, hard and brittle; cavities small, subglobose to irregular, empty; septa about 120–160 μ broad, made up of gelatinizing, branched, dilute melleus hyphae, scissile; basidia inconspicuous, clavate, 8–9$\times$3–4 μ, hyaline; sterigmata about half the length of the spores; spores acrogenous, hyaline, ellipsoidal, 6–7$\times$3 μ, smooth, 2-guttulate.

In dry pine woods. Italy and Alabama. January.

We were unable to locate the original description of *R. graveolens* but have based our determination on extracts from Vittadini quoted by Tulasne.

Specimen examined:

Alabama: Lee County, Auburn, *F. S. Earle* (in U. S. Dept. Agr., Bur. Pl. Ind. Path. Coll.).

10. Rhizopogon roseolus (Corda) Zeller & Dodge, comb. nov.

Splanchnomyces roseolus Corda in Sturm, Deutschl. Fl. **3**: 3–4. 1831; Icones Fung. **6**: 38. 1854.—*Rhizopogon rubescens* Tulasne, Giorn. Bot. Ital. **2**: 58. 1844 (in part), as also later writers.—*Mylitta roseola* Fries, Index Syst. Myc. 178. 1832; Summa Veg. Scand. **2**: 436 (note). 1849.

Illustrations: Corda in Sturm, Deutschl. Fl. **3**: *pl. 2;* Icones Fung. **6**: *pl. 7. f. 68;* Nees von Esenbeck, Th. F. L. & Henry, A. Syst. d. Pilze **1**: *pl. 10.*

Type: authentic specimen unknown to us, probably non-existent.

Fructifications globose to irregular, 1.5–3 cm. in diameter, cinnamon-buff to Verona brown and even blackening on drying; fibrils scanty or [illegible] appearing, innate-appressed, black when dry; peridium thin, 160–300 μ thick, compact, tawny under the microscope; gleba from warm buff to buckthorn-brown when dry, brittle; cavities subglobose and folded to labyrinthiform, empty; septa about 100 μ broad, made up of closely woven, branching, hyaline hyphae with thick gelatinized walls, not scissile; basidia ellipsoid, 12–13×7 μ, with small-lumened, heavily gelatini walls, mostly 1–2-spored, seldom 3–5; sterigmata 10–14 μ long; spores oblong to ellipsoid, acrogenous, dilute cream-colored under the microscope, heavy-walled, smooth, 2-guttulate, with an equatorially placed nucleus, making the spores appear 1-septate, 8–12×3–5.5 μ.

In Europe and the United States.

While we have not studied type material of *R. roseolus,* we feel confident that this species is the one which Corda had before him when he made his drawings. Owing to certain probable inaccuracies of representation, we have thought best to present drawings from American material.

Specimens examined:

Exsiccati: Ellis, N. Am. Fung., 943; Ell. & Ev., Fung. Col., cont. Shear, 1413.

Sweden: *C. G. Lloyd* (in Lloyd Mus., 03551).
Germany: Tilsit, *W. Krüger* (in Lloyd Mus., 06438 and 05197).
Massachusetts: *S. Davis* (in Coll. N. Y. State); Amherst, *S. J. Harkness* (in N. Y. Bot. Gard. Herb., 175).
New York: Ithaca, *W. R. Dudley, 17* (in Mo. Bot. Gard. Herb., 54976, and in Atkinson Herb., 21631); *H. H. Whetzel* (in N. Y. State Coll. Agr. at Cornell Univ., Dept. Pl. Path. Herb., 598, 2275); *H. H. Whetzel & D. Reddick* (in Atkinson Herb., 19415.).
New Jersey: Iona, *G. N. Copp,* in Ellis, N. Am. Fung., 943 (in Mo. Bot. Gard. Herb., Burt Herb., and N. Y. Bot. Gard. Herb., in part [see note under *R. rubescens,* p. 20]).
Maryland: Takoma Park, *C. L. Shear,* Ell. & Ev., Fung. Col., cont. Shear, 1413 (copies in Mo. Bot. Gard. Herb., Burt Herb., and U. S. Dept. Agr., Bur. Pl. Ind. Path. Coll.).
District of Columbia: Washington, *T. C. Wilcox* (in Coll. N. Y. State).
Tennessee: Rugby, *H. M. Caldwell, 1* (in Lloyd Mus., 7463); *M. S. Percival* (in Lloyd Mus., 7139).
Florida: *G. C. Fisher* (in Lloyd Mus., 07725); De Funiak Springs, *G. C. Fisher, 9, 10, 11,* in part[1] (in Lloyd Mus., 10619); Gainesville, *N. L. T. Nelson* (in Lloyd Mus., 171).
Alabama: Montgomery, *R. P. Burke* (in Lloyd Mus., 3 [or 4]); Spring Hill, *A. S. Bertholet* (in Lloyd Mus., 7127); Auburn, *G. F. Atkinson, 1038* (in Atkinson Herb.).
Mississippi: Ocean Springs, *H. G. McGowan* (in Lloyd Mus., 05812).
British Columbia: *J. U. Lloyd* (in Lloyd Mus., 6411).

11. **Rhizopogon induratus** Cooke, Grevillea 8 : 59. 1879.

Type: probably in Kew Herb.

Fructifications gregarious, depressed globose to irregular, "diameter 1–4 cm., color white, then pinkish, becoming dirty yellow or olivaceous" (McMurphy's field notes), drying black; fibrils inconspicuous to wanting above, large, free, rhizomorph-like below, often uniting several fructifications,

[1] Mr. Lloyd has these three numbers under the same number, some of the material being *Rhizopogon rubescens.*

concolorous with peridium or darker; peridium thin, 60–200 μ thick, simplex, context compact beneath, with cottony surface made up of branched brown hyphae 5–6.5 μ in diameter, claret-brown under the microscope; gleba at first white, then brownish olive, soft like heavy dough, finally drying hard like putty; cavities small, very irregular, mostly long-winding, about 60 μ in short diameter, filled with spores; septa narrow, 10–13 μ broad, hyaline, compact, not scissile; basidia inconspicuous, hyaline, 1–2-spored; sterigmata about one-half as long as spores; spores acrogenous, hyaline, ellipsoidal to narrowly ovate, 8–10$\times$3–5 μ, 1–2-guttulate, smooth, granular, with large nuclei mostly equatorially placed.

Emersed or submersed. Pacific coast, Australia, and New Zealand. November to March.

In the specimens examined, the peridium is thin, and the spores average larger than in Cooke's description, and Cooke describes the gleba as cinereous-fuscous, while in our specimens it is brownish olive.

Specimens examined:

Washington: Klickitat Co., Falcon Valley, *W. N. Suksdorf, 1001* (in Lloyd Mus., 05737).

California: Palo Alto, *J. McMurphy* (in Dudley Herb. at Leland Stanford Jr. Univ., Zeller Herb., 1405, and Dodge Herb., 838).

Australia: Sydney, Gladesville, *M. Flockton* (in Lloyd Mus., 11509).

12. Rhizopogon rubescens Tulasne, Giorn. Bot. Ital. **2**: 58. 1844; Fung. Hypog. 89–91. 1851; DeToni in Sacc. Syll. Fung. **7**: 161–162. 1888; Hesse, Hypog. Deutschl. **1**: 92–94. 1891.

Hysterangium rubescens Tulasne, Ann. Sci. Nat. II. **19**: 375. 1843.—*Rhizopogon luteolus* Krombholz, Nat. Abbild. u. Beschr. Schwämme **8**: 21. *pl. 60. f. 13–15.* 1843.—*Melanogaster Berkeleyanus* Broome, Ann. Mag. Nat. Hist. I. **15**: 41. 1845. —Not *Splanchnomyces roseolus* Corda in Sturm, Deutschl. Fl. **3**: 3–4. *pl. 2.* 1831.

Illustrations: Rehsteiner, Bot. Zeit. **50**: *pl. 11;* Tulasne, Fung. Hypog. *pl. 2. f. 1, pl. 11. f. 4.*

Type: location unknown to us.

Fructifications cespitose, ovate, or irregularly globose, 1–6 cm. in diameter when fresh, 1–5 cm. when dry, color white at first, then livid yellow, reddening in air (Tulasne), and drying Morocco red to claret-brown or almost black where touched; odor weak or almost none (Tulasne); fibrils inconspicuous, innate-appressed above, simple, large, rhizomorph-like below, at first white (Tulasne), then reddening and becoming almost black; peridium thin, about 160–220 μ, simplex, compact, brittle, very dark tawny; gleba at first white (Tulasne), then melleus to Isabella-color, brittle; cavities subglobose to labyrinthiform and irregularly crowded, empty; septa narrow, about 40–50 μ broad, hyaline, usually not scissile until old; basidia pyriform or clavate, 2–8-spored, 12–14 μ long; sterigmata about as long as the spores; spores acrogenous, ochraceous-tawny in mass, hyaline or cream-colored under the microscope, ellipsoidal, 5–10$\times$3–4.5 μ, 1–2-guttulate, smooth.

In sand under pines. Cosmopolitan. Autumn or winter, according to latitude.

Specimens examined:

Exsiccati: Roumeguère, Fung. Gall. Exsicc., 3826, under the name *Rhizopogon provincialis;* Ellis, N. Am. Fung., 943 (in U. S. Dept. Agr., Bur. Pl. Ind. Path. Coll., but not copies in Mo. Bot. Gard. Herb. nor in Burt Herb.).

Sweden: *C. G. Lloyd* (in Lloyd Mus., 03757).

Germany: Brandenburg, *O. Jaap, 12* (in Lloyd Mus., 03904).

England: Hampshire, Lundhurst, *C. E. Broome* (in Lloyd Mus., 1279).

France: Nice, *C. Roumeguère,* in Roumeguère, Fung. Gall. Exsicc., 3826 (in Mo. Bot. Gard. Herb., 5640); *Barla* (in Lloyd Mus., 5334).

Italy: Verona, S. Manro d' Saline, *C. Massalongo, 5* (in Lloyd Mus., 06084); Como, *O. Mattirolo, 8* (in Lloyd Mus., 03718).

Massachusetts: Boston, *H. Page* (in Lloyd Mus., 5899, 5900).

New York: Albany Co., Karner, *C. H. Peck* (in Coll. N. Y. State); Ithaca (in Atkinson Herb., 14053).

New Jersey: (in Lloyd Mus., 6179); Bakersville, *Mrs. G. M. Dallas* (in Lloyd Mus., 05881); Newfield, *J. B. Ellis,* Nov., 1879, Sept., 1880, Nov., 1881 (in N. Y. Bot. Gard. Herb., 175, in part); Iona, *G. N. Copp* (in N. Y. Bot. Gard. Herb., 175, in part), also issued as Ellis, N. Am. Fungi, 943[1] (in U. S. Dept. Agr., Bur. Pl. Ind. Path. Coll., but not in copies in Mo. Bot. Gard. Herb. nor Burt Herb.).

District of Columbia: Washington, *F. J. Braendle* (in Lloyd Mus., 05229).

Tennessee: Rugby, *H. M. Caldwell* (in Lloyd Mus., 7163); *Mrs. M. S. Percival* (in Lloyd Mus., 7119).

North Carolina: *M. A. Curtis* (in U. S. Nat. Herb.); Waynesville, *M. Fitzgerald* (in Lloyd Mus., 04216).

Florida: *G. C. Fisher, 2, 21* (in Lloyd Mus., 08355, 07866, respectively); De Funiak Springs, *G. C. Fisher* (in Lloyd Mus., 10621, 10619 in part [see note p. 17]); Cocoanut Grove, *A. S. Bertholet* (in Burt Herb.).

Alabama: Auburn, *F. S. Earle,* two collections (in N. Y. Bot. Gard. Herb.).

Texas: *Mrs. M. J. Young* (in N. Y. Bot. Gard. Herb.).

Iowa: Iowa City, *T. H. McBride* (in Lloyd Mus., 20 Hypogaei).

Washington: Cheney, *S. Tucker* (in Lloyd Mus., 08243).

California: Asilomar, *Walden & Cowles* (in Lloyd Mus., 1654, probably also in Pomona Coll. Herb., 1654); Pacific Grove, *M. L. Sutliff* (in Coll. N. Y. State); San Francisco, *N. L. Gardner* (in Zeller Herb., 1379, and Dodge Herb., 839).

Chile: Santiago, *M. Espinosa* (in Lloyd Mus., 5).

Japan: Sendai, *A. Yasuda, 166* (in Lloyd Mus., 13166).

West Australia: Leadersville, *F. Stoward, 9* (in Lloyd Mus.).

12a. Var. **Vittadinii** Tulasne, Fung. Hypog. 89. 1851.

[1] Ellis evidently mixed the collections which appear as "N. Y. Bot. Gard. Herb., 175" while they were still in his herbarium. Probably one collection was *R. roseolus* and the others *R. rubescens,* and the sets of the 'North American Fungi' were made up from the mixture. The portion studied was evidently put into a separate envelope, while the surplus material was placed in the box which contains a large number of fructifications, some of which are *R. roseolus* and some *R. rubescens.*

Hysteromyces vulgaris Vittadini, Notiz. nat. e civ. sulla Lombardia **1**: 341. 1844.

Type: unknown to us.

This variety differs from *R. rubescens* in that it has a thicker peridium (260–400 μ) which does not redden so distinctly on exposure to the air; the spores are smaller (6–8×3 μ); septa mostly as in *R. rubescens* but occasionally scissile. The hyphae of the fibrils are brown and septate with clamp connections.

Specimens examined:

Italy: Trentino, Coredo, Val d'Non, *M. Bezzi* (in Lloyd Mus., 08739).

Massachusetts: Boston, *S. Davis* (in Lloyd Mus., 5914, under the name *Rhizopogon roseus* Bresadola in herb., 5915).

Maryland: Georgetown, *H. H. Whetzel & Rhoads* (in Fitzpatrick Herb., 1152, N. Y. State Coll. Agr. at Cornell Univ., Dept. Pl. Path. Herb., 10158, Zeller Herb., 1406, and in Dodge Herb., 840).

Texas: Houston, *G. L. Fisher, 64* (in Lloyd Mus., 64).

Washington: Bingen, *W. N. Suksdorf, 807, 809* (in Lloyd Mus., 7296 and 7301, respectively).

EXTRA-LIMITAL SPECIES

The following are descriptions of species of *Rhizopogon* not as yet found in North America, but are included in order to assist in referring material to them in case they should be discovered later, as the individual species are found to have a very wide range. The descriptions in which no specimens are cited as having been examined, are compiled from the original descriptions, except as otherwise noted, and are translations or copies of them. As no material referable to them has been examined nor the types studied, we can form no opinion as to their validity.

1. **Rhizopogon violaceus** Cooke & Massee, Grev. **21**: 1. 1892; Saccardo, Syll. Fung. **11**: 170. 1895.

Type: *Kirk, 382* in Kew Herb. not studied.

Fructifications globose, drying angular, diameter up to 2.5 cm. when dry, vinaceous-fawn to fawn-color; no indica-

tion of fibrils; peridium very thick, 1–1.3 mm., simplex, coriaceous, very compact, made up of closely woven, very small hyphae, hyaline except for the violet bloom at the surface; gleba buffy citrine to Saccardo's olive; cavities globose to irregular, empty; septa about 75 μ in thickness, made up of closely woven, hyaline hyphae, not scissile; basidia clavate, inconspicuous, 7.5×15 μ, hyaline; sterigmata half as long as the spores; spores acrogenous, olivaceous in mass, oblong-ellipsoidal, 6–7×3–4 μ.

Submersed or partially emersed. Australia, New Zealand, and Japan.

This species is a very striking one. The gleba of dried specimens has a powdery appearance when cut, which, together with its very thick peridium, would lead one to place it in *Scleroderma*. The gleba cracks off from the peridium very readily when dry, and a study of sections shows a very definite cleavage plane formed by a layer of pseudoparenchyma between the gleba and the peridium. This feature suggests *Hysterangium* and would lead one to place it there as that genus was understood by DeToni in Saccardo, but there is no indication of a base or columella, which is considered an essential of this genus as understood by Tulasne and by Fisher in Engler & Prantl.

Specimens examined:

Australia: Victoria, Follett Co., *F. M. Reader, 8* (in Lloyd Mus., 06151).

Japan: Negoya, *J. Umemura* (in Lloyd Mus., 164, under the name *Hysterangium Phillipsii*).

2. **Rhizopogon Rodwayi** MacAlpine, Agr. Gaz. N. S. Wales **6**: 11. 1895; Saccardo, Syll. Fung. **14**: 267–268. 1899.

Illustration: MacAlpine, Agr. Gaz. N. S. Wales **6**: *pl. 4. f. 1–5.*

Type: location unknown to us.

Fructifications oblong, tuberiform, irregular, length up to 4 cm. (teste MacAlpine), 2–2.5 cm. broad, color from light pinkish cinnamon to cinnamon; fibrils very large, loose, prominent but scanty, concolorous or somewhat darker; peridium

variable in thickness from 90 to 180 μ in the same fructification, context cottony, made up of fine, brown hyphae loosely interwoven; gleba from pale ochraceous-salmon to zinc-orange; cavities globose to irregular, empty; septa 50–60 μ thick, hyaline, compact, not scissile; basidia inconspicuous, cylindrical, about 3 μ in diameter; sterigmata half the length of the spores; spores acrogenous, ellipsoidal, hyaline, smooth, 3–4×1 μ.

Hypogaeous. Tasmania and Australia.

Specimens examined:

Australia: Sydney, Gladesville, *M. Flockton* (in Lloyd Mus., 11509).

3. **Rhizopogon suavis** Quelet, Grev. **8**: 116. 1880; Assoc. Fr. Av. Sci. **12**: 508. 1883 (often cited as Champ. du Jura et des Vosges, Supplement **12**: 11. 1883); DeToni in Sacc. Syll. Fung. **7**: 163. 1888.

Illustrations: Quelet, Grev. **8**: *pl. 131. f. 3;* Assoc. Fr. Av. Sci. **12**: *pl. 7. f. 1* (Champ. du Jura et des Vosges, Suppl. **12**: *pl. 7. f. 1*).

Oblong, bullate, 1 cm. in diameter, tomentose, pale yellow (changing to brown when exposed to the air), adhering to chestnut-coloured fibres, which terminate in an arachnoid net; substance *compact,* elastic, hyaline, then olive, giving out a delicate odour of honey; cells rounded, with thin, white, silky walls; spores (5–7 on each basidium) pruniform, 5–7 μ, ochraceous, with two nuclei.

Summer. Woods on the lower hills of the Jura.

In the original description the diameter is given as "(.0–.01 mm.)," evidently a mistake, as the French version three years later gives it as "0^{m}, 01," i. e., 1 cm. The original gives the spores as "(.0005–.7 mm.)," the French as "(0^{mm}, 005–7)" now usually written "5–7 μ."

O. Jaap distributed as 'Flora der Provinz Brandenburg, 9,' under the name of *Rhizopogon virens* (A. & Schw.) from Triglitz i. d. Prignitz. This, however, is not *R. virens* as usually understood by European authors, and may be referred to *R. suavis* Quel., but we have seen no authentic material.

The description is rather too general to use in the identification of dried material. The specimen referred to above is the Lloyd Museum No. 03849. A collection in the Lloyd Museum from T. de Aranzadi, Barcelona, Spain, is conspecific with the above specimen.

4. Rhizopogon angustisepta Zeller & Dodge, sp. nov.

Fructificationes globosae vel irregulares, 0.8–1.0 cm. diametro siccatae metiens, "vinaceous-russet" vel "chocolate" aut etiam "Vandyke brown" (Ridgway), violaceo cum colore immixta; funiculi innati-applicati, fere nigri; peridium 460 μ crassitudine, duplex, strato extero 60–80 μ crassitudine, "ochraceous-buff" (Ridgway), minutis hyphis compacto, strato intero 380–400 μ crassitudine, "Mars brown" (Ridgway), hyphis maioribus granularibus contexto; gleba "cinnamon-brown" (Ridgway); locelli minuti, irregulares, vacui; septa pseudo-parenchymate compacta, 20–25 μ crassitudine inter hymenia; basidia hyalina in matrice gelatinosa, aequale cum superficie insita, ellipsoidea, di- vel tetraspora, sterigmatibus ex matrice proicientibus tam longis quam sporis; sporae ellipsoideae vel fusiformes, hyalinae, leves, 6–8×2–3 μ.

Habitat in Tilsit, Germania.

Type: in Lloyd Museum.

Fructifications globose to irregular, drying to 0.8–1.0 cm. in diameter, from vinaceous-russet to chocolate and even Vandyke brown with a violaceous tint; fibrils quite conspicuous, innate-appressed, almost black; peridium 460 μ thick, duplex, outer layer 60–80 μ thick, ochraceous-buff, of very fine compacted hyphae, inner layer 380–400 μ thick, Mars brown, of coarser granular hyphae; gleba cinnamon-brown; cavities small, irregular, empty; septa compact, composed of a very tight pseudo-parenchyma, 20–25 μ broad, not including the hymenium; basidia hyaline, embedded in a gelatinous matrix with an even surface, ellipsoidal, 2–4-spored; sterigmata protruding from the matrix, about as long as the spores; spores ellipsoidal to fusiform, hyaline, 6–8×2–3 μ.

In East Prussia.

Specimens examined:

Germany: East Prussia, *Wm. Krüger*, type (in Lloyd Mus., 6692, Dodge Herb., 833, and Zeller Herb., 1437).

5. Rhizopogon rubrocorticeus Zeller & Dodge, sp. nov.

Fructificationes globosae, 1.7–3.7 cm. diametro metiens, servatae "Hessian brown" (Ridgway) saepe cum "coral-pink" (Ridgway) maculis, siccatae "Verona brown" vel "snuff-brown" (Ridgway), tactu nigrescentes; funiculi pauci, liberi, subramosi, prominentes, "Hessian brown" (Ridgway) vel saturatiores; peridium crassum, 600–800 μ crassitudine, simplex, "russet" vel "ox-blood-red" et "claret-brown" (Ridgway), hyphis septatis, granulis coloratis impletis, contextum; gleba albida recens, "light buff" (Ridgway) sicca; locelli irregulares, vacui aut nonnulla ex parte recens impleti; septa hyalina, 60–70 μ crassitudine, cellulis pseudoparenchymatibus confecta, non scissilia; basidia late ovate, 6–10×10–13 μ, sterigmatibus 3–6 μ longitudine munita; sporae acrogenae, "cream-buff" (Ridgway) acervatae, ellipsoideae, 5–6.5×3–4 μ, saepe diguttulatae.

Habitat in Mauritio Insula.

Type: in Lloyd Museum, Zeller Herb., and Dodge Herb.

Fructifications globose, 1.7–3.7 cm. in diameter, with a distinct reddish appearance in preserved specimens, Hessian brown (often with spots of coral-pink), on drying becoming Verona brown to snuff-brown and almost black where bruised; fibrils few, free, somewhat branched, very prominent, Hessian brown to darker; peridium 600–800 μ thick, simplex, russet to ox-blood-red and claret-brown, of septate hyphae containing pigmented granules; gleba white when fresh, drying to light buff; cavities irregular, medium size, empty or partially filled when young; septa hyaline, 60–70 μ broad, compact, composed of pseudo-parenchyma, not scissile; basidia hyaline, broadly ovate, 6–10×10–13 μ; sterigmata about as long as the spores; spores cream-buff in mass, appearing hyaline when alone, ellipsoidal, mostly 2-guttulate, 5–6.5×3–4 μ.

In Mauritius.

Specimens examined:

Mauritius: Le Reduit Gardens, *C. A. O'Connor* (in Lloyd Mus., 06217, type, 06316, and 12191, under the name *Anthracophlous rhizopogonoides.*

6. Rhizopogon Briardi Boudier, Bull. Soc. Bot. France **32**: 284–285. 1885; Icones Myc. **4**: 97. 1911; De Toni in Sacc. Syll. Fung. **7**: 163. 1888.

Illustrations: Boudier, Bull. Soc. Bot. France **32**: *pl. 9. f. 5;* Icones Myc. **1**: *pl. 190.*

Type: unknown to us.

Fructifications globose to irregular, 1–2.5 cm. in diameter, apricot-buff to Hay's russet; fibrils scanty, inconspicuous, innate-appressed, darker than the peridium; peridium 440–580 μ thick, duplex, outer layer warm buff under the microscope, about 240 μ thick, composed of loosely woven hyphae, easily separable, leaving inconspicuous patches, inner layer madder-brown under the microscope, about 200–340 μ thick, composed of a stupose mat of hyphae; gleba tawny to russet; cavities globose to irregular, medium size, empty; septa hyaline, about 40 μ broad, composed of pseudo-parenchyma; basidia inconspicuous, hyaline; sterigmata short; spores honey-yellow in mass, appearing light creamy singly, 1–2-guttulate, 6.5–8$\times$ 3.5–5 μ.

Specimens examined:

Exsiccati: Roumeguère, Fung. Gall. Exsicc., 3661.

Sweden: *L. Romell* (in Lloyd Mus., 04351).

France: Champagne, near Troyes, *Major Briard,* in Roumeguère, Fung. Gall. Exsicc., 3661 (in N. Y. Bot. Gard. Herb.); Aube, *L. Hemet* (in Lloyd Mus., 10734).

Austria: Tyrol, Mendel Pass, *G. Bresadola & W. A. Murrill* (in N. Y. Bot. Gard. Herb.).

7. **Rhizopogon virescens** Karsten in Sacc. Syll. Fung. **9**: 280. 1891.

Rhizopogon virens Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **25**: 354–355. 1876 (or Myc. Fenn. **3**: 354–355. 1876); *Ibid.* **48**: 18–19. 1889 (or Krit. Öfversigt af Finl. Basidsv. 18–19. 1889).—But not of other authors.

Peridium lobate, difform, commonly oblong-sphaeroidal, bearded with loose, radicating fibrils below, at first white, then dirty spadiceous, becoming greenish ashy within; spores oblong, straight, smooth, 10–16$\times$4–6 μ.

Habitat: in pine woods by sandy roadside. Syrjöås, near Mustiala. August and September, 1865 and 1870.

Infrequent. Odorless. Diam. 1.5 cm.

8. **Rhizopogon lapponicus** Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48** : 19. 1889 (or Krit. Öfversigt af Finl. Basidsv. 19. 1889); Saccardo, Syll. Fung. **9** : 280. 1891.

Rhizopogon luteolus Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **25** : 354. 1876 (or Myc. Fenn. **3** : 354. 1876).

Peridium difform, commonly sphaeroid, reniform or ovoid, with loose, radicating fibrils, at first white, then light yellow or dirty yellow, within becoming yellow; spores ellipsoid, dilute yellowish or subhyaline, smooth, straight, 7–10×4–5 μ. . . . .

Hab. wooded areas in earth, very rare. So far, I have collected it on the Island Runsala near Åbo and at Knäsäguba in southern Russian Lapponia. Summer and autumn.

—Karsten.

Sparse or gregarious. About 2 cm. in diameter. Odor and taste nauseous.

There seems little in the above description to distinguish it from *R. rubescens*. The type should be carefully studied.

9. **Rhizopogon Webbii** Tulasne, Fung. Hypog. 91. 1851; De Toni in Sacc. Syll. Fung. **7** : 164. 1888.

Rhizopogon albus Montagne in Webb & Bertholet, Hist. Nat. des Iles Canar. III. **2**[4]: 85. 1841.—*Splanchnomyces Webbiana* Corda, Icones Fung. **6** : 40. 1854.

Illustrations: Corda, Icones Fung. **6** : *pl. 8. f. 74.*

Fructification rotund, difform, lobate-depressed, confluent, smooth, from white becoming brown, with fibrillose base, 2–2.5 cm. in diameter; peridium testaceous-fulvous, smooth, thin; gleba fulvous-alutaceous, firm, compact; cavities narrow, bent, meandriform; septa pale luteous, homogeneous; hymenium greenish; sterigmata short; spores cylindric, ellipsoid, smooth, rounded at each end, olivaceous, .0003 p. p. p. long (teste Corda).

Habitat: under fallen leaves of *Pinus canariensis* in high places, Chasna and elsewhere in the Canary Islands. Edible.

The above description was drawn up from a combination of the references given above. Both Montagne and Tulasne state that the specimens, preserved in alcohol, were sterile and young. The Corda description was probably drawn up by

Zobel, who edited the final volume of the 'Icones' after Corda's death. Zobel states that the description is based on a specimen received from Montagne.

10. **Rhizopogon piceus** Berk. & Curt. Am. Acad. Arts & Sci. Proc. **4**: 124. 1860 (often cited as Fung. N. Pac. Exped. No. 114); De Toni in Sacc. Syll. Fung. **7**: 163–164. 1888.

Beardless, peridium at length black; gleba alutaceous-umber; spores oblong.

Habitat: mountain valleys near Hong Kong, China.

This very brief description must await a study of the type material before it will be a usable species name.

11. **Rhizopogon borealis** Karsten, Soc. pro Fauna et Fl. Fenn. Meddel. **13**: 161–162. 1886 (or Symb. Myc. Fenn. **17**: 161–162. 1886); Finska Vet.-Soc. Bidrag Natur och Folk **48**: 19–20. 1889 (or Krit. Öfversigt af Finl. Basidsv. 19–20. 1889); De Toni in Sacc. Syll. Fung. **7**: 164. 1888.

Peridium difform, unequal, white, brown on drying, testaceous or lurid within, fleshy, without fibrils (?) (nuda), at least when dry, 2–3 cm. in diameter; spores oblong or ellipsoid, 2- or rarely 4-guttulate, hyaline, straight, 5–8×2–3 μ.

In sandy soil near Ulaburg (*H. S. Zidbäck*).

12. **Rhizopogon aestivus** Fries, Syst. Myc. **2**: 294. 1823.

Lycoperdon aestivum Wulfen, Pl. Rar. Carinth. **5**: No. 133, in Jacquin, Coll. Bot. Chem. Hist. Nat. **1**: 349–351. 1786.

This species is given by Tulasne as a synonym of *R. rubescens* in his original description and antedates it by twenty years, but it seems unwise to reduce *R. rubescens* to synonymy until the types can be studied, especially since the latter name has been the only one in use since it was proposed in 1844. The Friesian description is in such general terms that it would apply to several different species.

13. **Rhizopogon virens** (Albertini & Schweinitz) Fries, Syst. Myc. **2**: 294. 1823.

Tuber virens Albertini & Schweinitz, Consp. Fung. Lusat. 77. *pl. 8. f. 3.* 1805.

This species has had such a varied history that only a careful study of types can untangle the synonymy. The plate cited above and early descriptions seem to make it synonymous with *R. luteolus* Fr. & Nordh. which it antedates by ten years. Writers from Tulasne to DeToni include it among the synonyms of that species. Hesse thinks it a separate species.

14. Rhizopogon albus Fries, Syst. Myc. **2** : 293–294. 1823.

As in the preceding, the synonymy here is very involved, and type material must be studied. The Friesian species is usually said to be an ascomycete, but as we have been unable to find it reduced to synonymy until all the other descriptions of *Rhizopogon albus* were published, this seems to prevent the use of *R. albus* to designate other species, and they have mostly been transferred or renamed. (See excluded species.)

15. Rhizopogon dubius (Corda) DeToni in Sacc. Syll. Fung. **7** : 164. 1888.

Splanchnomyces dubius Corda, Icones Fung. **6** : 38. 1854.

Illustration: Corda, Icones Fung. **6** : *pl. 7. f. 70.*

This is for me a doubtful species; I have not seen it, and it could not be found among Corda's specimens; Corda did not make a drawing of the whole fungus as he usually did, and his original drawing shows only what is reproduced here. Only the spore size is noted in Corda's handwriting, 3.4–3.9 μ.

I can only inform my readers that as may be seen from the drawing, the (smooth) peridium may be dirty purple red, the septa dirty yellow, the hymenium bright yellow, the spores colorless. . . . .

I suppose that Corda had only a fragment of this fungus to work with. It probably grows in Böhmen.

The almost pure yellow of the gleba and the narrow, labyrinthiform cavities separate this species from the previous and the following ones. —Zobel.

EXCLUDED SPECIES

1. Rhizopogon albus Berkeley in Smith, Brit. Fl. **5**[2]: 299. 1836, is *Hymenogaster Klotzschii* Tulasne Fung. Hypog. 64–65. 1851.

2. Rhizopogon albus Corda in Sturm, Deutschl. Fl. Abt. III. Heft 19–20 : 43–46. *pl. 14.* 1841, is *Choeromyces meandriformis* Vittadini, Mon. Tub. 51. *pl. 2. f. 1, pl. 4. f. 10.* 1831.

3. **Rhizopogon Leonis** Payer, Bot. Crypt. 100. *f. 462.* 1850, is *Terfezia Leonis* Tulasne, Ann. Sci. Nat. III. **3** : 350. 1845; and in Durieu de Maison-Neuve, Expl. Sci. de l'Alg. Bot. **1** : 432. *pl. 24. f. 22–30.* 1846–1849.

4. **Hydnangium aurantium** (Harkness) Zeller & Dodge, comb. nov.

Rhizopogon aurantius Harkness, Proc. Cal. Acad. Sci. III. **1** : 257. 1899; Saccardo, Syll. Fung. **16** : 251. 1902.

Type: in Dudley Herb. at Leland Stanford Jr. Univ.

Fructifications solitary, subglobose, 2 cm. in diameter, "dirty white when fresh" (Harkness), drying yellowish (the specimens in alcohol, however, are dark brown); peridium 180–200 μ thick, homogeneous, but outer hyphae becoming brown; gleba "orange when fresh" (Harkness), now (Dec., 1917) auburn when wet with alcohol, becoming pale orange-yellow when drying out; cavities globose, large in the center, empty; septa 150 μ thick, composed of gelatinizing, closely woven, hyaline hyphae, scissile; basidia clavate, hyaline, gelatinous, 2–8-spored; sterigmata 10–11 μ long, slender; spores dilute olivaceous to subhyaline, rough, globose, 15 μ in diameter (8–10 μ, teste Harkness).

In dense forests of *Sequoia.* California. August.

Specimens examined:

California: Marin County, Mt. Tamalpais, *H. W. Harkness, 74,* type (in Dudley Herb. at Leland Stanford Jr. Univ.).

EXPLANATION OF PLATE

PLATE 1

Fructifications of species of *Rhizopogon* (natural size).

Fig. 1. *R. provincialis* showing the prominent, free fibrils.

Fig. 2. *R. graveolens* showing the characteristic surface and usual shape of the fructifications.

Fig. 3. *R. maculatus* showing fibrils.

Fig. 4. *R. luteolus* showing the innate fibrils.

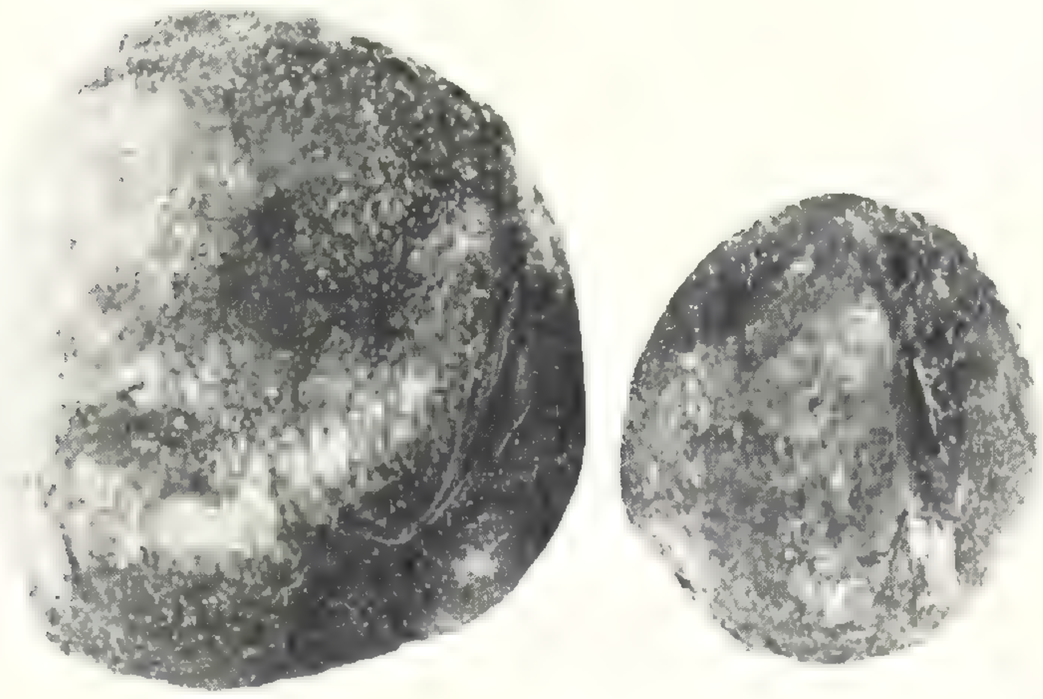
Fig. 5. *R. roseolus* showing the dark peridium and scanty fibrils.

Fig. 6. *R. pannosus* showing the "patches" or remains of the outer peridium.

Fig. 7. *R. occidentalis* showing the prominent, innate-appressed fibrils.

Fig. 8. A fructification of *R. pachyphloeus* showing both the black cut surface and the external surface with reticulated, innate fibrils.

Fig. 9. *R. rubescens* var. *Vittadinii* showing the nature of the fibrils.



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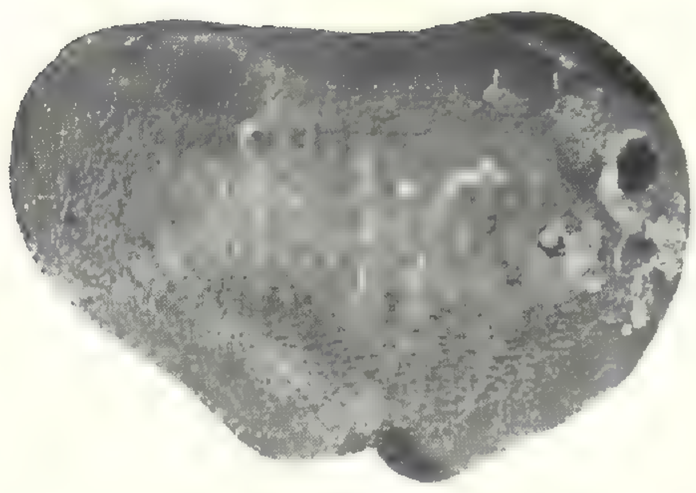

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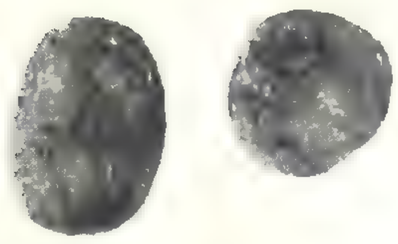

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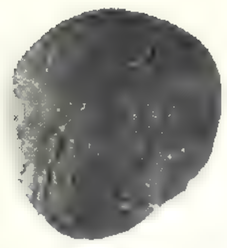

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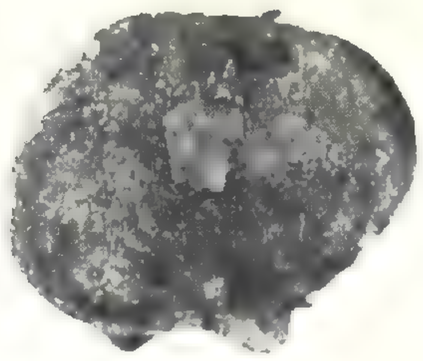

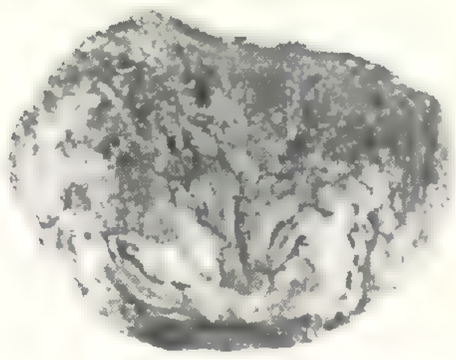

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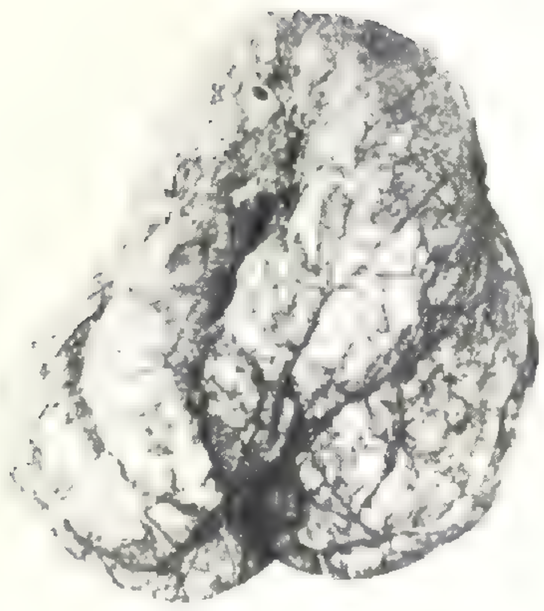

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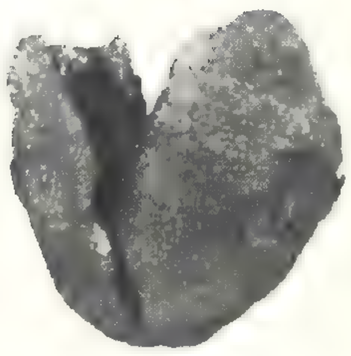

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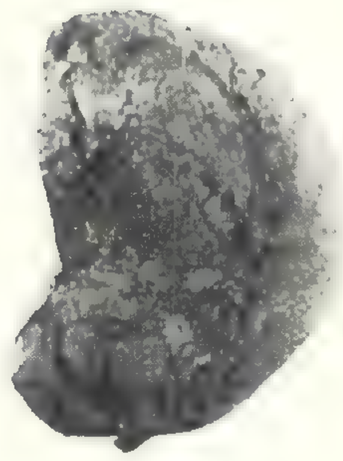


9

ZELLER AND DODGE — RHIZOPOGON

Explanation of Plate

PLATE 2

Fig. 1. Diagrammatic section of *Rhizopogon maculatus*, showing the duplex character of the peridium and its relation to the gleba; × 120.

Fig. 2. Basidia of *R. maculatus;* × 800.

Fig. 3. Diagrammatic section of *R. pannosus*, showing the duplex peridium, the cracking of the outer layer to form the "patches," and the relation of the peridium and gleba; × 10.

Fig. 4. Basidia of *R. pannosus;* × 830.

Fig. 5. Diagrammatic section of *R. diplophloeus*, showing general relation of parts; × 10.

Fig. 6. Showing bulbous hyphae of the outer peridial layer of *R. diplophloeus;* × 200.

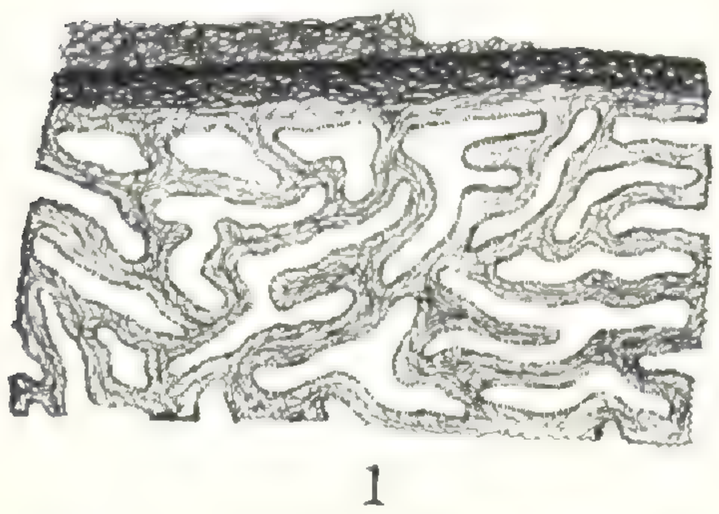
Fig. 7. Basidia of *R. diplophloeus;* × 800.

Fig. 8. Diagrammatic section of *R. pachyphloeus;* × 10.

Fig. 9. Basidia and spores of *R. pachyphloeus;* × 800.

Fig. 10. Diagrammatic section of *R. occidentalis*, showing the relation of the peridium to the gleba and the scissile character of the septa; × 30.

Fig. 11. Basidia of *R. occidentalis;* × 800.



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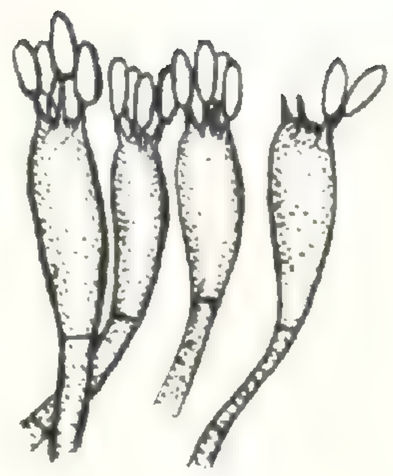

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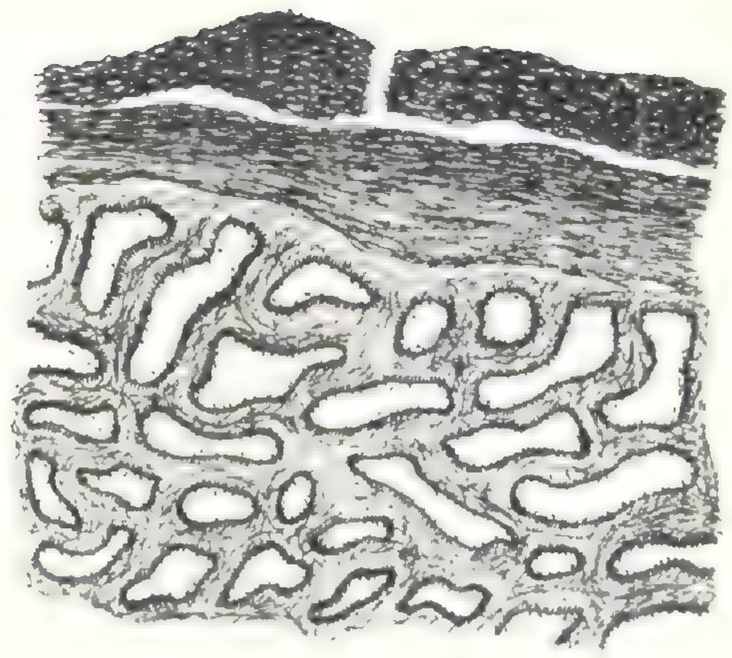

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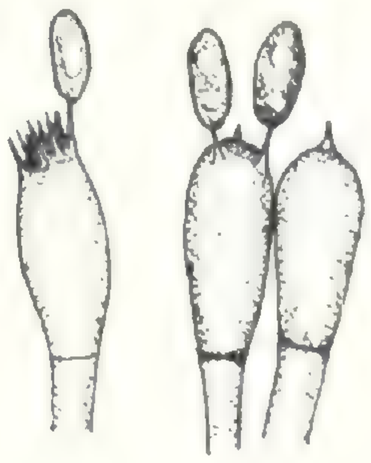

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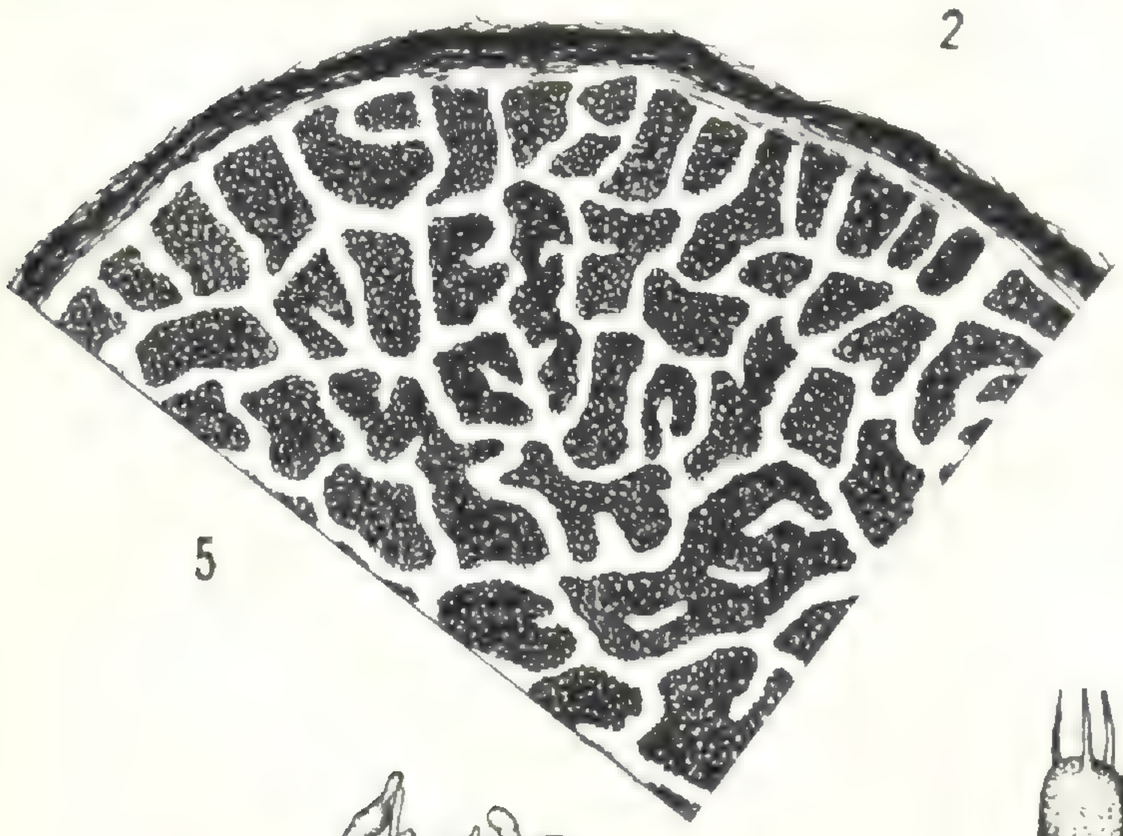

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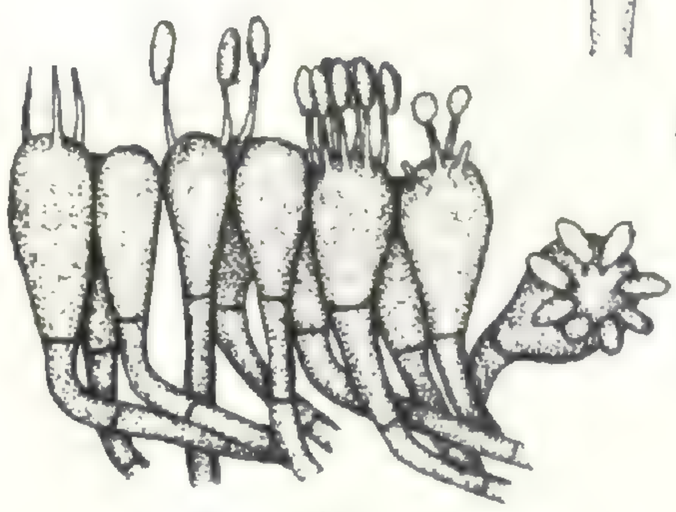

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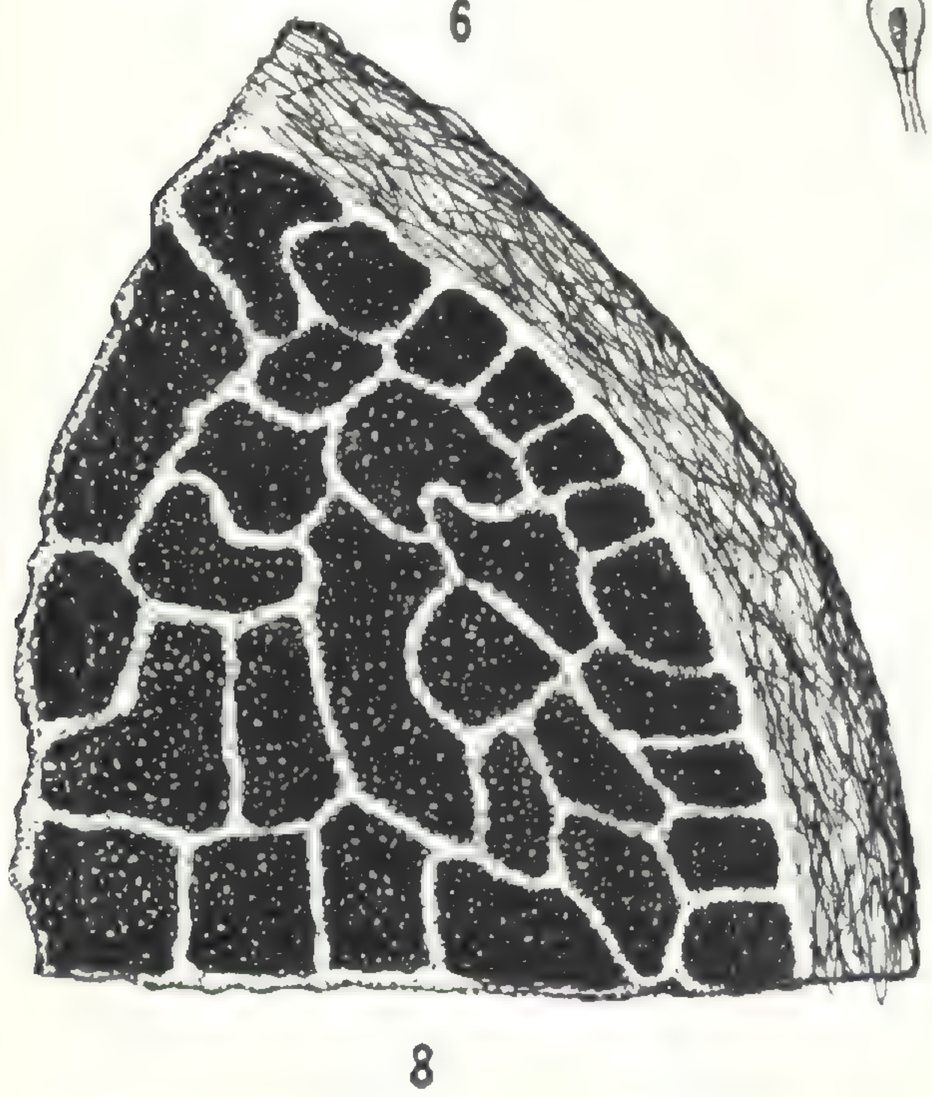

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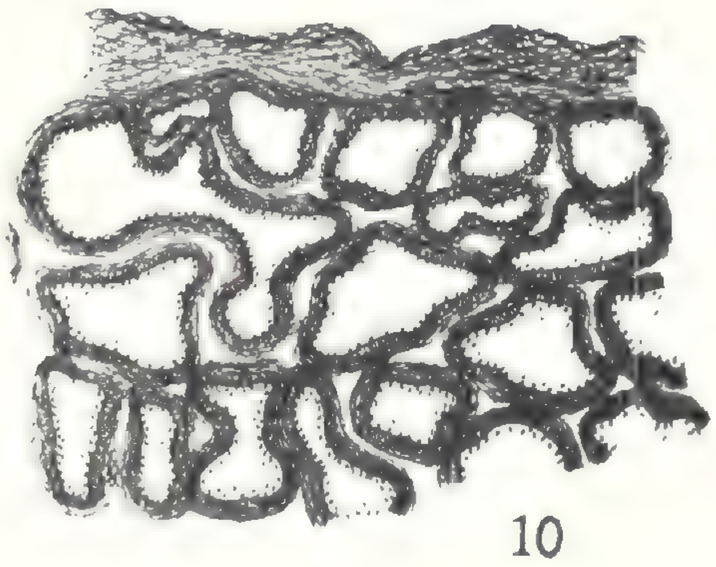

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11

Explanation of Plate

PLATE 3

Fig. 1. Diagrammatic section of *Rhizopogon roseolus;* × 10.

Fig. 2. Showing the gelatinized basidia and long sterigmata of *R. roseolus;* × 800.

Fig. 3. Showing nuclear positions in the spores of *R. roseolus;* × 2400.

Fig. 4. Diagrammatic section of *R. induratus;* × 100.

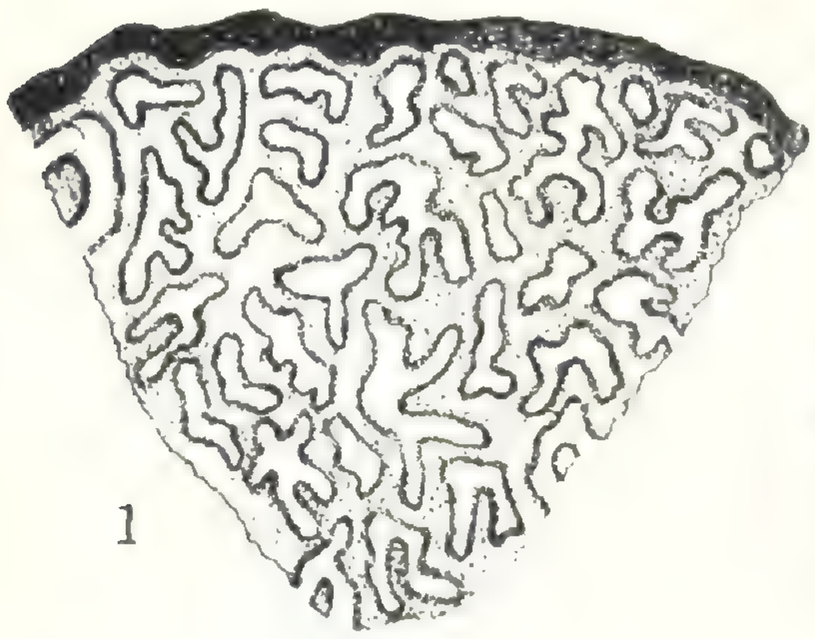
Fig. 5. Showing the basidia and spores of *R. induratus;* × 800.

Fig. 6. Diagrammatic section of *R. angustisepta;* × 50.

Fig. 7. Showing basidia of *R. angustisepta* embedded in a gelatinous matrix, and spores; ×830.

Fig. 8. Diagrammatic section of *R. rubrocorticeus;* × 10.

Fig. 9. Showing basidia and spores of *R. rubrocorticeus;* × 830.



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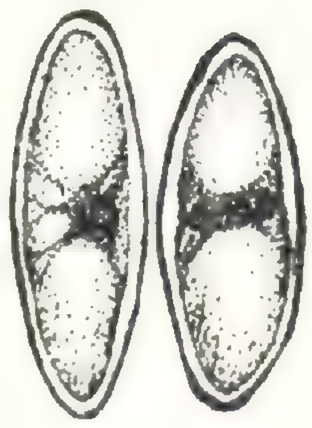

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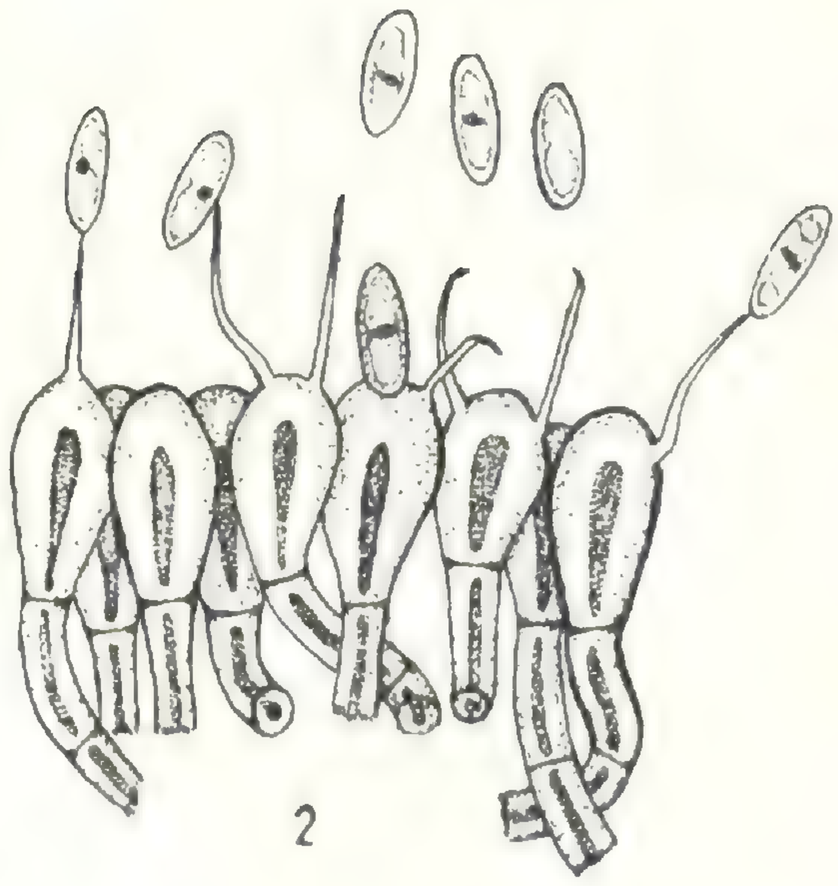

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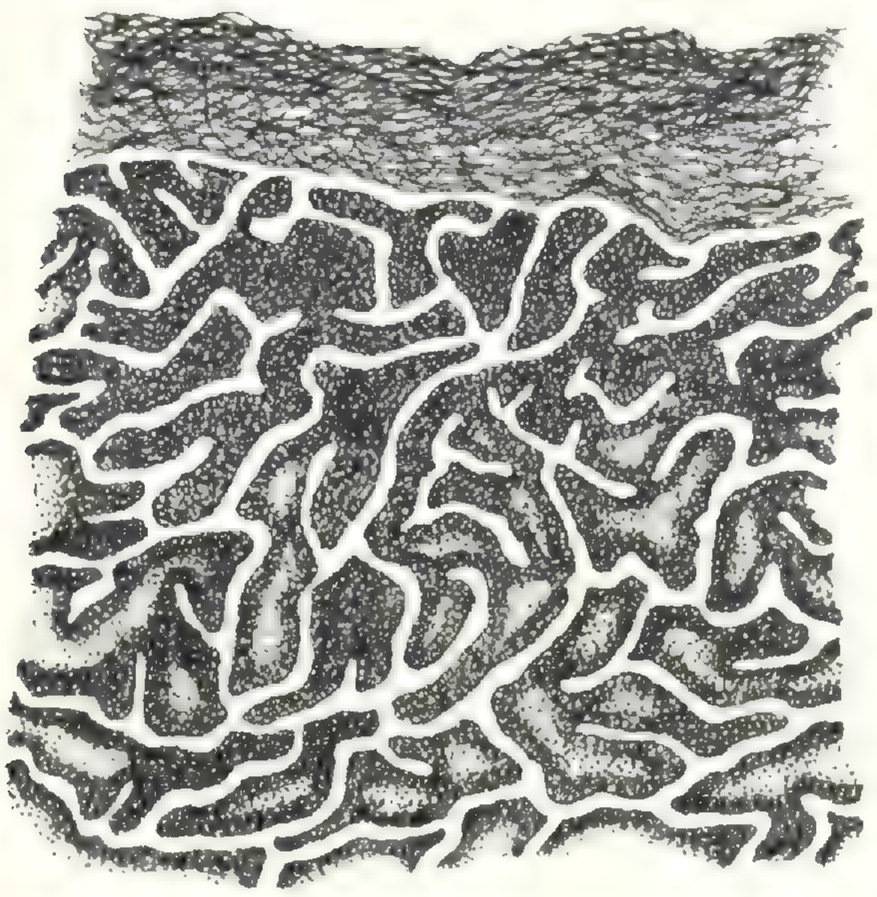

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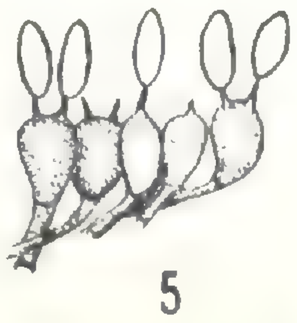

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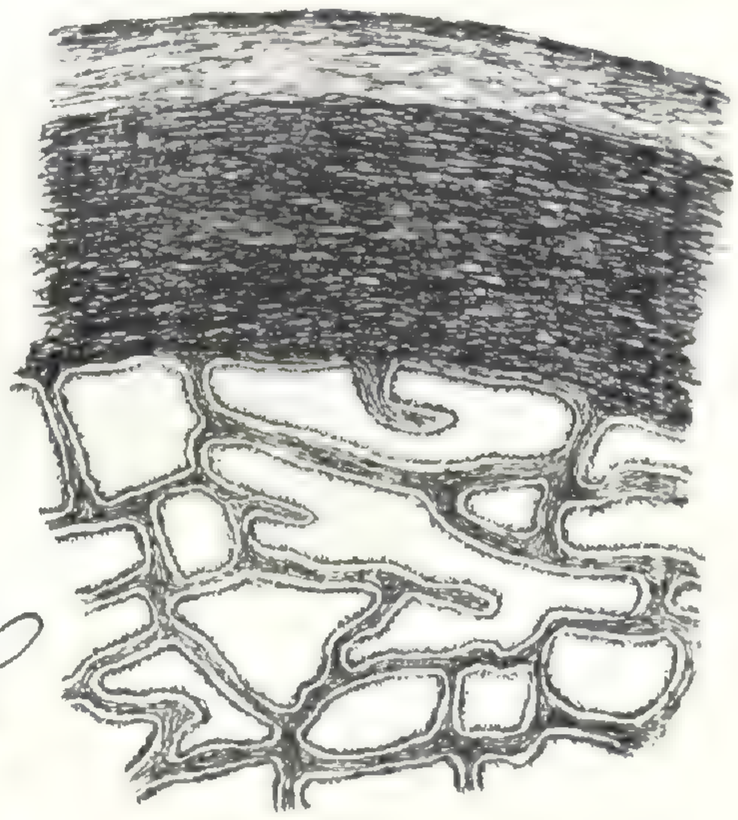

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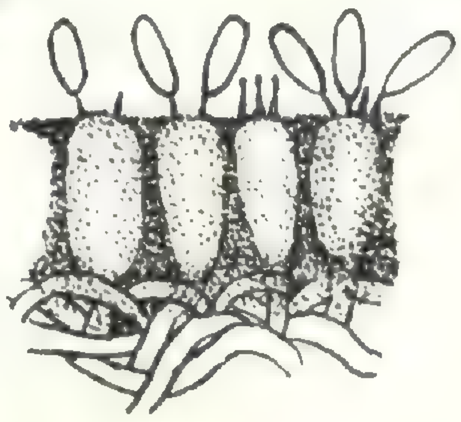

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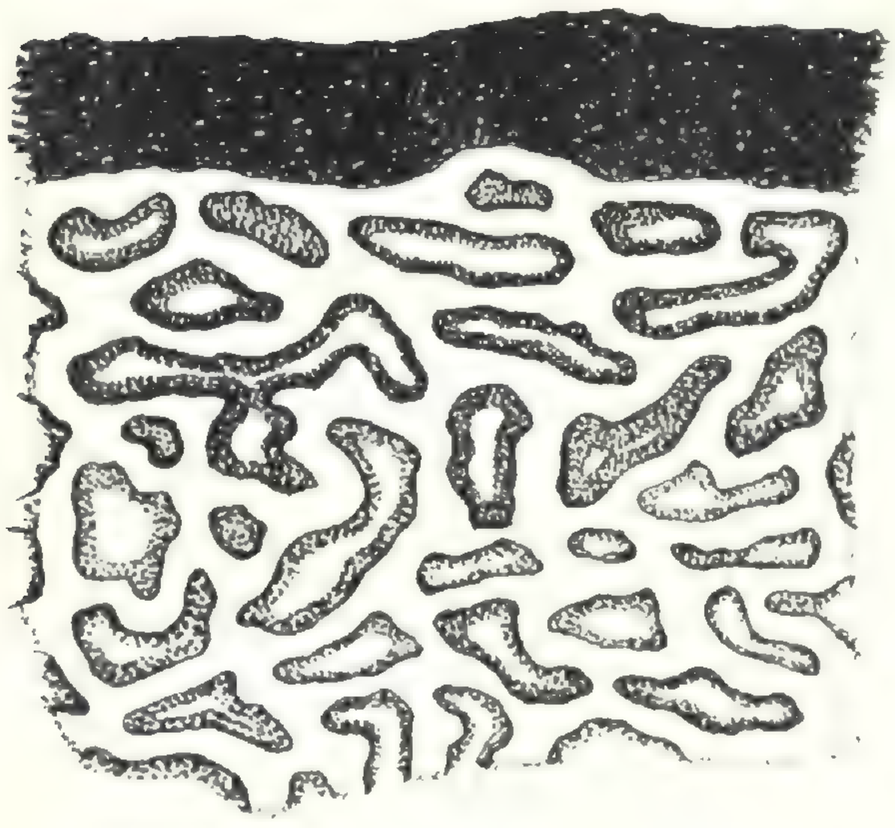

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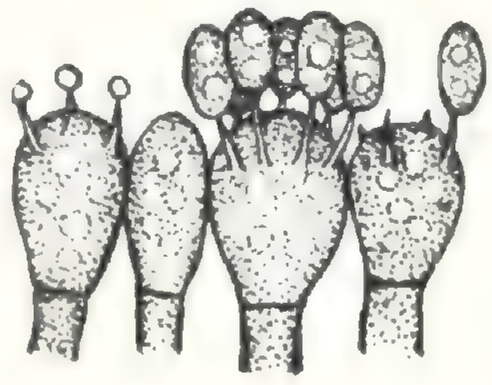

9

ZELLER AND DODGE — RHIZOPOGON

MONOGRAPH OF THE NORTH AND CENTRAL AMERICAN SPECIES OF THE GENUS SENECIO—PART II[1]

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Professor in the Henry Shaw School of Botany of
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Sect. 8. Tomentosi Rydb.

§ 8. Tomentosi Rydb. Bull. Torr. Bot. Club **27** : 184. 1900, in major part; Greenm. Monogr. Senecio, I. Teil, 22, 24, 29. 1901, and in Engl. Bot. Jahrb. **32** : 18, 20, 25. 1902.

Perennial and usually cespitose herbs with erect or ascending stems, densely and permanently white-tomentose throughout, or tomentose in the early stages and more or less glabrate in age; inflorescence a few to many-headed corymbose cyme; heads radiate or discoid; achenes glabrous or hirtellous. Sp. 97–131.

Key to the Species

A. Plants at first tomentose, soon more or less glabrate especially on the upper leaf-surface; inflorescence several-headed; heads 8 to 12 mm. high.
  a. Basal leaves ovate, 2 to 5.5 cm. broad, often subcordate ..... *97. S. arizonicus*
  b. Basal leaves obovate to oblanceolate, .5 to 2.5 cm. broad, not at all cordate.
    a. Stems 1.5 to 6 dm. high; leaves sinuate-dentate to lyrate; offshoots short or subsessile.
      I. Stem leafy at base, nearly naked above; leaves not sharply dentate.
        1. Plants sordid-tomentulose ..... *98. S. sordidus*
        2. Plants white-tomentose, more or less glabrate.
          * Leaf-blade much longer than broad.
            † Leaves more or less lyrate; achenes hirtellous or glabrous.
              0. Achenes hirtellous. *99. S. neo-mexicanus*
              00. Achenes glabrous.. *99a.* var. *Griffithsii*

[1] Issued April 3, 1918.

Note.—The present paper is continued from Ann. Mo. Bot. Gard. 4 : 15–36. 1917.

†† Leaves not at all lyrate; achenes hirtellous or glabrous.
0. Achenes hirtellous. *100.* *S. oresbius*
00. Achenes glabrous. *101.* *S. Hartmanii*
** Leaf-blade nearly or quite as long as broad. *102.* *S. bernardinus*

II. Stems tending to be more uniformly leafy; leaves subentire to sharply dentate.
1. Plants of New Mexico; achenes glabrous. *103.* *S. eurypterus*
2. Plants of Colorado and New Mexico; achenes hirtellous. *104.* *S. mutabilis*

β. Stems 1 to 6 dm. high; leaves slightly dentate to sinuately subbipinnate with deep rounded sinuses and usually blunt lobes; stems tending to be leafy and to produce numerous slender offshoots. *105.* *S. Fendleri*

γ. Stems .5 to 1.5 dm. high; leaves not at all lyrate, entire or dentate towards the apex.
I. Leaves rotund-ovate to spatulate-linear; achenes glabrous or very rarely hirtellous.
1. Plants of the Sierra Nevada Mountains. *106.* *S. Muirii*
2. Plants of the Rocky Mountains.
* Leaf-blade nearly as broad as long.
† Heads radiate. *107.* *S. saxosus*
†† Heads discoid. *107a.* var. *toiyabensis*
** Leaf-blade usually much longer than broad.
† Heads radiate. *108.* *S. werneriaefolius*
†† Heads subdiscoid. *108a.* var. *incertus*
II. Leaves linear; achenes hispidulous. *109.* *S. Thurberi*

B. Plants at first tomentose, soon more or less glabrate especially on the upper leaf-surface; inflorescence one to few-headed; heads 12 to 20 mm. high.
a. Leaves thick in texture; rays pale yellow.
α. Leaf margin not revolute.
I. Involucral bracts 10–13 mm. long. *110.* *S. Actinella*
II. Involucral bracts 7–8 mm. long. *111.* *S. molinarius*
β. Leaf-margin strongly revolute. *112.* *S. gerberaefolius*
b. Leaves thin in texture; rays deep orange. *113.* *S. Greenei*

C. Plants mostly permanently white-tomentose; inflorescence several-headed; heads 10 to 12 mm. high.
a. Pubescence subappressed-sericeous. *114.* *S. convallium*
b. Pubescence white floccose-lanate.
α. Lowermost leaves obovate to ovate, not at all cordate. *115.* *S. Leonardii*
β. Lowermost leaves ovate to oblong-lanceolate, occasionally subcordate. *116.* *S. tomentosus*
γ. Lowermost leaves obovate to oblanceolate, not at all cordate.
I. Stems 1 to 5 dm. high; leaves chiefly basal (except in *S. Harbourii*).

1. Plants of the United States.
   * Species of eastern United States; achenes hirtellous....*117. S. antennariifolius*
   ** Species of western United States; achenes glabrous.
      † Petioles of the basal leaves shorter than the blade; bracts of the involucre about 21 .....*118. S. canus*
      †† Petioles of the basal leaves usually longer than the blade; bracts of the involucre about 13.
         || Radical leaves oblong-oblanceolate to narrowly oblanceolate (except in *S. Howellii* var. *lithophilus*).
            0. Plants of the Rocky Mountains.
               δ. Heads 10 to 12 mm. high; involucral bracts 7 to 10 mm. long .....*119. S. Harbourii*
               δδ. Heads 8 to 10 mm. high; involucral bracts 5 to 7 mm. long .....*120. S. Purshianus*
            00. Plants of Washington, Oregon, and the Great Basin.
               δ. Leaves narrow, .5 to 1.5 cm. wide; heads radiate .....*121. S. Howellii*
               δδ. Leaves broader, .5 to 3 cm. wide; heads radiate ....*121a.* var. *lithophilus*
               δδδ. Heads discoid .....*121b.* var. *eradiatus*
         || || Radical leaves ovate.
            0. Heads radiate.....*122. S. oreopolus*
            00. Heads discoid.....*122a.* f. *aphanactis*
         || || || Radical leaves spatulate .....*123. S. Hallii*
2. Plants of Mexico.
   * Foliage densely and permanently white-tomentose .....*124. S. candidissimus*
   ** Foliage usually somewhat glabrate .....*125. S. bellidifolius*

II. Stems 3 to 10 dm. high, more or less leafy stemmed.
1. Leaves relatively narrow, .5 to 1.5 cm. in width.
* Leaves discolorous .....*126. S. loratifolius*
** Leaves not discolorous.
† Stem-leaves auriculate at the base .....*127. S. cynthioides*
†† Stem-leaves not auriculate at the base.....*128. S. fastigiatus*
2. Leaves relatively broad, 1.5 to 4 cm. in width.
* Plants of Mexico.....*129. S. umbraculifer*
** Plants of northwestern United States.
† Involucral bracts about 8; achenes glabrous .....*130. S. atratus*
†† Involucral bracts about 21; achenes hirtellous .....*131. S. sphaerocephalus*

97. S. arizonicus Greene, Bull. Torr. Bot. Club **10**: 87. 1883; Gray, Syn. Fl. N. Am. **1**^{2}: 392. 1884, and ed. 2, 1886, excl. plant of Pringle; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902.

An herbaceous perennial; stems erect or nearly so, 1.5 to 4 dm. high, from a stoutish caudex, at first white-tomentose, soon glabrate above, permanently so at the base; lower leaves ovate to ovate-lanceolate, including the narrowly winged petiole 5 to 15 cm. long, 2 to 5.5 cm. broad, often subcordate, acute, unequally dentate, loosely floccose-tomentose in the early stages, more or less glabrate; upper stem-leaves sessile, lance-attenuate, somewhat clasping the stem, often much reduced and bract-like; inflorescence a subcorymbose cyme; heads 8 to 12 mm. high, radiate; involucre slightly calyculate; bracts of the involucre 13 to 21; ray-flowers 9 to 12, rays yellow; disk-flowers rather numerous; achenes slightly hirtellous.

Distribution: Arizona and New Mexico.

Specimens examined:

Arizona: Prescott, coll. of 1876, *E. Palmer 264* (Gray Herb.); Lynx Creek, 31 May, 1883, *Rusby* (Gray Herb. and U. S. Nat. Herb. Nos. 47595, 47596), TYPE.

New Mexico: Ruidoso Creek, White Mountain region, Lincoln Co., alt. 2030 m., 29 June, 1895, *Wooton* (U. S. Nat. Herb. No. 735294).

98. S. sordidus Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902.

S. neo-mexicanus Gray, Proc. Am. Acad. **19** : 55. 1883; Syn. Fl. N. Am. **1**^{2}: 392. 1884, and ed. 2, 1886, in part, as to plant of Greene.

An herbaceous perennial; stem erect, 5 to 6 dm. high, tawny tomentulose at the base and in the leaf-axils, nearly glabrous above, somewhat striate and more or less purplish; radical and lower stem-leaves petiolate, oblong-oblanceolate in general outline, including the petiole 5 to 10 cm. long, 1 to 2.5 cm. broad, sublyrate and rather coarsely serrate-dentate, tawny tomentulose on both surfaces, somewhat glabrate above; upper stem-leaves gradually reduced, becoming sessile and bracteiform at the corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate, glabrous or nearly so; involucral bracts about 21, linear-lanceolate, 6 to 7 mm. long, often purplish-tipped; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: southwestern New Mexico.

Specimens examined:

New Mexico: dry wooded hills, near Silver City, 10 May, 1880, *E. L. Greene* (Gray Herb.), TYPE.

99. S. neo-mexicanus Gray, Proc. Am. Acad. **19** : 55. 1883; Syn. Fl. N. Am. **1**^{2}: 392. 1884, and ed. 2, 1886, mainly; Rydb. Bull. Torr. Bot. Club **27** : 186. 1900, in part; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902; Wooton & Standley, Contr. U. S. Nat. Herb. **19** : 747. 1915, in part. Pl. 4, fig. 1.

S. aureus var. *borealis* Gray, Pl. Wright., pt. 2, p. 100. 1853, and in Bot. Mex. Bound. Surv. 103. 1859, not Torr. & Gray.

S. Toumeyi Greene, Pittonia **3** : 349. 1898.

S. willowensis Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902.

S. Blumeri Greene, Leafl. Bot. Obs. & Crit. **2** : 20. 1909.

S. Encelia Greene, Leafl. Bot. Obs. & Crit. **2** : 22. 1909.

An herbaceous perennial, more or less white-tomentose throughout; stems one to several from a short stoutish perpendicular or ascending rootstock, erect, 1.5 to 5.5 dm. high, white-tomentose below, sometimes becoming glabrous or nearly so above, striate; radical and lower stem-leaves petiolate, obovate to oblanceolate, 2 to 10 cm. long, .5 to 3 cm. broad, subentire to lyrate, at first densely white-tomentose on both surfaces, later more or less glabrate, thick in texture and often tinged with purple; upper stem-leaves sessile, irregularly dentate, gradually reduced towards the corymbose inflorescence; heads numerous, 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre usually 21, linear-lanceolate, 6 to 8 mm. long, tomentulose to nearly glabrous; ray-flowers 10 to 13, rays yellow; disk-flowers numerous; achenes hirtellous.

Distribution: mountains of New Mexico and Arizona.

Specimens examined:

New Mexico: Organ Mountains, coll. of 1852, *Wright 1415* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.), TYPE; without definite locality, coll. of 1847, *Fendler 479* (Gray Herb.); Mimbres, coll. of 1853, *Dr. Henry* (Gray Herb.); Mogollon Mountains, Aug., 1881, *Rusby 212* (Mo. Bot. Gard. Herb.); Santa Magdalena Mountains, coll. of 1881, *Vasey* (U. S. Nat. Herb.); between Santa Fé and Cañoncito, alt. 2225 m., 23 June, 1897, *A. A. & E. G. Heller 3749* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Organ Mountains, 25 May, 1898, *C. L. Herrick 232* (U. S. Nat. Herb.); Burro Mountains, Grant Co., alt. 1825 m., 20 June, 1903, *Metcalfe 195* (U. S. Nat. Herb., Mo. Bot. Gard. Herb., and Univ. Ariz. Herb.); Organ Mountains, Dona Ana Co., 25 April, 1907, *Wooton 3370* (U. S. Nat. Herb.); Sandia Mountains, 2 May, 1914, *Ellis 22* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Arizona: Mazatzal Mountains, coll. of 1867, *Dr. E. Smart* (U. S. Nat. Herb.); without definite locality, coll. of 1869, *Dr. E. Palmer* (U. S. Nat. Herb. No. 49345); Fort Lowell, coll. of 1880, *Lemmon 122* (Gray Herb.); Santa Catalina Mountains, April, 1880, *Lemmon* (Gray Herb.); Santa Catalina Moun-

tains, May, 1881, *Lemmon* (Univ. Chicago Herb. at Field Mus. No. 352207); Santa Rita Mountains, 2 May, 1881, alt. 1675 m., *Pringle* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); Lynx Creek, 31 May, 1883, *Rusby 665* in part (U. S. Nat. Herb.); Santa Catalina Mountains, 6 May, 1883, alt. 1220 m., *Pringle* (Gray Herb., U. S. Nat. Herb., and Phil. Acad. Nat. Sci. Herb.); high mountains, 14 May, 1884, *W. F. Parish 125* (Gray Herb.); Fort Huachuca, coll. of 1890, *Dr. Patzky* (U. S. Nat. Herb.); Willow Spring, 10–20 June, 1890, *Dr. E. Palmer* (Gray Herb.); Fort Huachuca, 26 April–21 May, 1890, *Dr. E. Palmer 438* (U. S. Nat. Herb.); Pinal Mountains, 26 May, 1890, *M. E. Jones* (U. S. Nat. Herb. No. 220118, and Mo. Bot. Gard. Herb.), *type* of *S. Encelia* Greene; Santa Catalina Mountains, 19 May, 1892, *Toumey 689* (U. S. Nat. Herb.); Chiricahua Mountains, 20 Sept., 1896, *Toumey 130* (Greene Herb., Univ. of Notre Dame), *type* of *S. Toumeyi* Greene; vicinity of Flagstaff, alt. 1675 m., 31 May, 1898, *MacDougal 12* in part (Gray Herb.); Flagstaff, 6 June, 1901, *L. F. Ward* (U. S. Nat. Herb. No. 410253); hills above Rosemont, 13 March–23 April, 1903, *Griffiths 4139* (U. S. Nat. Herb.); Santa Catalina Mountains, Sabino Cañon, 9 April, 1905, *Thornber & Terrell* (Univ. Ariz. Herb.); stony knolls, Barfoot Park, Chiricahua Mountains, alt. 2435 m., June, 1907, *Blumer 151* (U. S. Nat. Herb. No. 561506), *type* of *S. Blumeri* Greene; same locality, 1 July, 1907, *Blumer 1553* (U. S. Nat. Herb., Mo. Bot. Gard. Herb., Field Mus. Herb., and Univ. Ariz. Herb.); Santa Catalina Mountains, 15 April, 1908, *J. N. Rose 11815* (U. S. Nat. Herb.); Miller's Cañon, Huachuca Mountains, 8 June, 1909, *Goodding 108* (Univ. Ariz. Herb.); steep slopes, Huachuca Mountains, May, 1912, *Goodding 1307* (U. S. Nat. Herb. and Univ. Ariz. Herb.); near Soldier Camp, Santa Catalina Mountains, Pima Co., alt. 2345 m., 16 May, 1914, *Shreve* (Mo. Bot. Gard. Herb.); Oak Camp, Santa Catalina Mountains, Pima Co., alt. 1425 m., 19 May, 1914, *Shreve* (Mo. Bot. Gard. Herb.).

Var. **Griffithsii** Greenm. var. nov.

S. arizonicus Gray, Syn. Fl. N. Am. 1^2: 392. 1884, and ed. 2, 1886, in part, not Greene, i.e. as to plant of Pringle.

Stems erect, 2.5 to 4.5 dm. high, simple or branched; leaves and inflorescence similar to the species; achenes glabrous.

Specimens examined:

Arizona: Santa Rita Forest Reserve, 31 March–23 April, 1903, *David Griffiths 4212* (Mo. Bot. Gard. Herb.), TYPE; Santa Rita Mountains, alt. 1675 m., 2 May, 1881, *Pringle* (Gray Herb.); near Fort Huachuca, coll. of 1894, *T. E. Wilcox 19* (U. S. Nat. Herb.).

100. S. oresbius Greenm. nom. nov.

S. oreophilus Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902, name only; Ann. Mo. Bot. Gard. **1** : 267. 1914, not Dusén.

An herbaceous perennial; stem solitary, erect, about 2.5 dm. high, tomentulose; leaves chiefly basal, rather numerous, petiolate, oblong-cuneate, including the petiole 3 to 9 cm. long, .5 to 2.5 cm. broad, subentire to sinuate-dentate towards the rounded apex, at first white-tomentulose, soon glabrate; stem-leaves few, much reduced, sessile, somewhat auriculate at the base, slightly expanded and dentate towards the apex; inflorescence a terminal corymbose cyme; heads numerous, about 1 cm. high, radiate; involucre campanulate, sparingly calyculate, slightly tomentulose at the base, otherwise glabrous; bracts of the involucre about 21, linear-lanceolate, 7 to 8 mm. long; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes hirtellous.

Distribution: known only from the type locality.

Specimen examined:

New Mexico: Pinos Altos Mountains, 6 May, 1880, *E. L. Greene* (Gray Herb. and Greene Herb., Univ. of Notre Dame), TYPE.

101. S. Hartmanii Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902.

An herbaceous perennial, more or less floccose-tomentose throughout; stems one to several from a perpendicular or ascending rootstock, 1.5 to 3.5 dm. high, simple, somewhat glabrate above, striate; leaves mostly basal, obovate to oblanceolate, 2 to 10 cm. long, .5 to 3 cm. broad, entire to crenate-

dentate, abruptly to gradually contracted below the middle into a narrowly winged petiole, at first densely white-tomentose, later glabrate, thickish in texture and often more or less tinged with purple; upper stem-leaves much reduced, sessile, oblanceolate to linear and bracteiform; inflorescence a terminal corymbose few to several-headed cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate, tomentulose to nearly glabrous; bracts of the involucre about 21, linear-lanceolate, 6 to 8 mm. long; ray-flowers 13, rays yellow; disk-flowers numerous, 50 to 70; achenes glabrous.

Distribution: northern Mexico.

Specimens examined:

Chihuahua: Puerta de St. Diego, alt. 1980 m., 12 April, 1891, *C. V. Hartman 623* (Gray Herb. and U. S. Nat. Herb.), TYPE.

Sonora: Guadalupe Cañon, *E. K. Smith* (Gray Herb. and Field Mus. Herb. No. 42927); without definite locality, coll. of 1890, *C. E. Lloyd 405* (Gray Herb.).

102. S. bernardinus Greene, Pittonia **3** : 298. 1898; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902.

S. ionophyllus var. *bernardinus* Hall, Univ. Calif. Pub. Bot. **3** : 232. 1907.

S. neo-mexicanus Gray, Proc. Am. Acad. **19** : 55. 1883; Syn. Fl. N. Am. **1**^{2}: 392. 1884, and ed. 2, 1886, in part, as to plant of Parish.

An herbaceous perennial, at first floccose-tomentose throughout, more or less glabrate; stems one to several, 1.5 to 3 dm. high, simple or branched; leaves mostly basal, usually numerous, often forming a rather dense rosette, round-ovate, obovate to spatulate-cuneate, 2 to 6 cm. long, .5 to 1.5 cm. broad, thick in texture, entire or dentate towards the apex, narrowed at the base into a slender petiole much exceeding the blade, and occasionally bearing a pair of small lobes at the base of the blade, the older persistent leaves becoming nearly or quite glabrous; upper stem-leaves few, more or less reduced, narrowly cuneate and dentate towards the apex to linear-lanceolate and entire; inflorescence a terminal few to

several-headed corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate, tomentulose; bracts of the involucre 13 to 21, linear-lanceolate, 6 to 9 mm. long; ray-flowers 8 to 10, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of southern California.

Specimens examined:

California: Bear Valley, San Bernardino Mountains, alt. 1980 m., Aug., 1882, *S. B. & W. F. Parish 1450* (Greene Herb., Univ. of Notre Dame, Gray Herb., and U. S. Nat. Herb.), TYPE; Bear Valley, alt. 1980 m., 23 June, 1894, *S. B. Parish 3345* (Greene Herb., Univ. of Notre Dame, U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Bear Valley, 16–20 June, 1895, *S. B. Parish 3718* (Greene Herb., Univ. of Notre Dame, and Gray Herb.); Bear Valley, 5 Aug., 1902, *Abrams 2891* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); San Bernardino Mountains, Aug.-Sept., 1907, *Mrs. C. M. Wilder* (Dudley Herb., Stanford Univ. No. 82450); Bear Valley, alt. 1825 m., July, 1909, *Davidson 2159* (U. S. Nat. Herb.); Holcomb Valley, San Bernardino Mountains, alt. 2130 m., 16 June, 1916, *S. B. Parish 10878* (Mo. Bot. Gard. Herb.).

Var. **sparsilobatus** (Parish) Greenm. comb. nov.[1]

S. sparsilobatus Parish, Bot. Gaz. **38**: 462. 1904.

White floccose-tomentose throughout, slightly glabrate; stems 1.5 to 2 dm. high, erect; stem-leaves, except the uppermost, petiolate, 1 to 6 cm. long, 1 to 1.5 cm. broad, pinnately lobed with remote entire or dentate lobes; heads 10 to 12 mm. high; involucral bracts about 13; achenes glabrous.

Specimens examined:

California: trail from Barton Flats to South Fork of Santa Ana River, alt. 2130 m., June, 1904, *Mrs. H. E. Wilder* (Dudley

[1] An examination of the type specimen of *Senecio sparsilobatus* Parish, which has been loaned to me from the Dudley Herbarium, through the courtesy of Professor Leroy Abrams, shows this plant to be more closely allied to *S. bernardinus* Greene than to *S. ionophyllus* Greene; it accordingly has been so treated above. The several specimens cited under *S. ionophyllus* var. *sparsilobatus* in my recent paper, indicated below, represent a marked variation from the type of this species and for these may be substituted the name **Senecio ionophyllus** Greene var. **intrepidus** Greenm. nom. nov. (*S. ionophyllus* var. *sparsilobatus* Hall, Univ. Calif. Pub. Bot. **3**: 232. 1907; Greenm. Ann. Mo. Bot. Gard. **4**: 34. 1917, not *S. sparsilobatus* Parish).

Herb., Stanford Univ. No. 82451), TYPE; San Bernardino Mountains, July, 1904, *Mrs. H. E. Wilder* (U. S. Nat. Herb. No. 444995).

103. S. eurypterus Greenm. nom. nov.

S. appendiculatus Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902, name only; Ann. Mo. Bot. Gard. **1** : 265. 1914, not DC.

S. neo-mexicanus Gray, Proc. Am. Acad. **19** : 55. 1883; Syn. Fl. N. Am. 1^2: 392. 1884, and ed. 2, 1886, in part, as to plant of Thurber; Wooton & Standley, Contr. U. S. Nat. Herb. **19** : 747. 1915, in part.

An herbaceous perennial, more or less white-tomentose throughout; stems one to several from an ascending or erect rootstock, 1.5 to 4 dm. high, at first tomentose, later somewhat glabrate, subfoliaceous; leaves oblong-obovate to oblanceolate, including the petiole 2 to 14 cm. long, .5 to 2.5 cm. broad, usually sharply dentate, rarely entire, in the younger stages white-tomentose on both surfaces, later more or less glabrate; stem-leaves similar, the uppermost sessile and usually amplicated into an irregularly dentate subauriculate half-clasping base; inflorescence a terminal few to several-headed corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, minutely calyculate, sparingly tomentulose; bracts of the involucre about 21, linear-lanceolate, 5 to 7 mm. long; ray-flowers about 13, rays yellow; disk-flowers numerous, 60 to 70; achenes glabrous.

Distribution: mountains of New Mexico.

Specimens examined:

New Mexico: Mule Spring, May, 1851, *Thurber 280* (Gray Herb.), TYPE; without definite locality, *Mexican Boundary Survey 662* (U. S. Nat. Herb.); Santa Magdalena Mountains, coll. of 1881, *Vasey* (U. S. Nat. Herb. Nos. 49347, 156602); Organ Mountains, Dona Ana Co., 25 April, 1895, *Wooton* (U. S. Nat. Herb.); Filmore Cañon, Organ Mountains, Dona Ana Co., 29 April, 1899, *Wooton* (U. S. Nat. Herb.); Organ Mountains, Dona Ana Co., coll. of 1900, *Wooton* (C. C. Deam Herb.); Van Patten's, Organ Mountains, 9 June, 1906, *Standley* (U. S. Nat.

Herb. and Mo. Bot. Gard. Herb.); Organ Mountains, 25 April, 1907, *Wooton 3370* (Mo. Bot. Gard. Herb.); Lake Valley, coll. of 1915, *Mrs. W. G. Beals* (U. S. Nat. Herb.).

104. S. mutabilis Greene, Pittonia **4**: 113. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 583, 1909, in part, excl. synonymy; Wooton & Standley, Contr. U. S. Nat. Herb. **19**: 747. 1915.

S. cognatus Greene, Pittonia **4**: 114. 1900.

S. aurellus Rydb. Bull. Torr. Bot. Club **27**: 182. 1900.

An herbaceous perennial, usually loosely floccose-tomentulose; stems one to several from an ascending or perpendicular rootstock, erect or nearly so, 1.5 to 4 dm. high; leaves obovate to oblanceolate, including the petiole 2 to 12 cm. long, .5 to 1.5 cm. broad, rounded at the apex, subentire, dentate or sublyrate, at first white-tomentulose on both surfaces, later more or less glabrate; stem-leaves similar, more or less reduced, oblanceolate to narrowly lanceolate, distinctly petiolate to sessile, somewhat laciniate to entire; inflorescence a terminal few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate, glabrous or slightly tomentulose; bracts of the involucre 13 to 21, linear-lanceolate, 5 to 7 mm. long; ray-flowers 8 to 12, rays yellow; disk-flowers 40 to 60; achenes hispidulous.

Distribution: Colorado to Arizona.

Specimens examined:

Colorado: Arboles, June, 1899, *C. F. Baker 712, 713* (Greene Herb., Univ. of Notre Dame, Gray Herb., Berlin Herb., and Mo. Bot. Gard. Herb.), TYPE; Los Pinos, May, 1899, *C. F. Baker* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Cimarron, alt. 2000 m., 6 June, 1901, *C. F. Baker 19, 33* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Marshall Pass, alt. 3045 m., 19 July, 1901, *C. F. Baker 516* (Gray Herb., Univ. Calif. Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Rico, alt. 2895 m., 1 July, 1898, *Colo. State Agr. Coll. 3046* (U. S. Nat. Herb.); Surface Creek, Delta Co., alt. 2040

m., May, 1892, *Purpus 76* (Univ. Chicago Herb. at Field Mus.); La Plata Cañon, alt. 2740 m., 11 July, 1898, *Baker, Earle & Tracy 469* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Mancos, alt. 2130 m., 23 and 24 June, 1898, *Baker, Earle & Tracy 63* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Mancos, alt. 2130 m., 24 June, 1898, *Baker, Earle & Tracy 998* (Mo. Bot. Gard. Herb. and U. S. Nat. Herb.), *type* of *S. aurellus;* Harmon's Lake, 24 July, 1898, *Baker, Earle & Tracy 999* (Mo. Bot. Gard. Herb.); Piedra, 11 July, 1899, *C. F. Baker* (Greene Herb., Univ. of Notre Dame, U. S. Nat. Herb., Kew Herb., and Mo. Bot. Gard. Herb.), *type* of *S. cognatus.*

New Mexico: High Rolls and vicinity, alt. 1825 m., 21–28 May, 1902, *H. L. Viereck 30* (Phil. Acad. Nat. Sci. Herb.); hills south of Tierra Amarilla, Rio Arriba Co., alt. 2300 m., 18 April–25 May, 1911, *Eggleston 6546* (U. S. Nat. Herb.); pass southeast of Tierra Amarilla, alt. 2320 m., 18 April–25 May, 1911, *Eggleston 6602* (U. S. Nat. Herb.).

Arizona: Apache Verde Road, east of Baker Butte, 1 June, 1900, *Coville 1043* (U. S. Nat. Herb.).

105. S. Fendleri Gray, Mem. Am. Acad. N. S. [Pl. Fendl.] **4**: 108. 1849; Pac. Rail. Rept. **4**: 111. 1856; Proc. Acad. Nat. Sci. Phil. p. 68. 1863; Syn. Fl. N. Am. **1**^{2}: 392. 1884, and ed. 2, 1886; Coulter, Manual Rocky Mountain Region, 211. 1885; Greene, Pittonia **4**: 112. 1900; Rydb. Bull. Torr. Bot. Club **27**: 188. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902; Rydb. Fl. Colo. 396. 1906; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 581. 1909, in part; Daniels, Univ. Mo. Studies, Sci. Ser. **2**: 251. 1911; Clements & Clements, Rocky Mountain Flowers, 293. 1914; Wooton & Standley, Contr. U. S. Nat. Herb. **19**: 746. 1915.

S. Nelsonii Rydb. Bull. Torr. Bot. Club **26**: 483. 1899, and **27**: 172. 1900; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 581. 1909.

S. salicinus Rydb. Bull. Torr. Bot. Club **27**: 186. 1900.

S. rosulatus Rydb. Bull. Torr. Bot. Club **27**: 188. 1900.

S. Fendleri lanatus Osterhout, Bull. Torr. Bot. Club **31**: 358. 1904.

S. lanatifolius Osterhout, Bull. Torr. Bot. Club **32**: 612. 1905; Daniels, Univ. Mo. Studies, Sci. Ser. **2**: 252. 1911.

S. rosulatus mut. *primulinus* Cockerell, Torreya **13**: 272. 1913.

S. confertus Nelson in Herb.

S. rosulatus coryphocolus Clements in Herb.

An herbaceous perennial, at first white-tomentose, somewhat glabrate; stems one to several, erect or nearly so, simple or branched, 1 to 6 dm. high, frequently bearing short or elongated and slender offshoots at the base of the stem and becoming densely cespitose, uniformly leafy or with the upper leaves more or less reduced; lower leaves petiolate, oblanceolate to oblong-ovate in general outline, 2 to 12 cm. long, .5 to 3.5 cm. broad, subentire to sinuately lobed or even subbipinnate with deep rounded sinuses and crowded, often somewhat crenate or plaited, rounded and entire to acutely dentate lobes, more or less glabrate especially on the upper surface; upper leaves sessile, similar or reduced to lanceolate, dentate to subentire bracts; inflorescence a terminal several to many-headed corymbose cyme; heads 7 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre usually 13, linear-lanceolate, 4 to 6 mm. long, tomentulose to glabrous; ray-flowers 7 to 12, rays yellow; disk-flowers 30 to 40; achenes glabrous.

Distribution: Wyoming to New Mexico.

Specimens examined:

Wyoming: Wind River Mountains, 9 Aug., 1894, *A. Nelson* (Gray Herb.); Pole Creek, hillside, Table Mountains, 2 June, 1894, *A. Nelson 124* (Gray Herb.); on granite slopes, Sand Creek, Albany Co., 30 June, 1900, *A. Nelson 6996* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); dry gravelly slopes, Centennial, Albany Co., 27 July, 1902, *A. Nelson 8697* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Green Top, 29 June, 1897, *A. Nelson 3217* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Cummins, 28 July, 1895, *A. Nelson 1492* (Gray Herb., U. S. Nat. Herb., and Mo.

Bot. Gard. Herb.); foothills west of Islay, alt. 3050 m., 25 June, 1909, *Merritt Cary 321* (U. S. Nat. Herb.); near Cheyenne, 25 June, 1896, *E. L. Greene* (Greene Herb., Univ. of Notre Dame); near Sherman, 29 July, 1893, and 29 June, 1896, *E. L. Greene* (Greene Herb., Univ. of Notre Dame, Nos. 47410, 47409).

Colorado: foothills west of Fort Collins, alt. 1675 m., 24 May, 1896, *C. F. Baker* (Mo. Bot. Gard. Herb.); Front Range, alt. 3050 m., 8 July, 1896, *Crandall* (Mo. Bot. Gard. Herb.); tributaries of the South Fork of the Cache la Poudre River, July, 1896, *Pammel 285* (Mo. Bot. Gard. Herb.); Chamber's Lake, alt. 2895 m., 1 Aug., 1896, *C. F. Baker* (Mo. Bot. Gard. Herb. and Greene Herb., Univ. of Notre Dame, No. 47406); rocky ridges, Pinkham Creek, 7 July, 1903, *Goodding 1484* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Livermore, Larimer Co., 27 May, 1897, *Osterhout 33* (Greene Herb., Univ. of Notre Dame); Estes Park, 28 June, 1912, *Churchill* (J. R. Churchill Herb. and Mo. Bot. Gard. Herb.); Estes Park, 10 Aug., 1912, 22 June, 1913, and 10 June, 1916, *E. L. Johnston 754, 448,* and *717* (Mo. Bot. Gard. Herb.); Estes Park, 22 June, 1913, *E. L. Johnston 854, 894* (U. S. Nat. Herb.); dry hills, Estes Park, coll. of 1913, *Cockerell* (U. S. Nat. Herb. No. 693295); Lyons, 24 May, 1916, *E. L. Johnston 814B, 818B* (Mo. Bot. Gard Herb.); Allenspark, alt. 2560 m., 16 July, 1917, *Johnston & Hedgcock 173* (Mo. Bot. Gard. Herb.); Central City, colls. of July, 1884, and 17 Aug., 1885, *Letterman* (Mo. Bot. Gard. Herb.); along railroad track, Tolland, alt. 2740 m., 2 July, 1913, *Overholts* (Mo. Bot. Gard. Herb.); dry soil, Eldorado Springs, alt. 1615 m., 24 June, 1917, *Clokey 2812* (I. W. Clokey Herb. and Mo. Bot. Gard. Herb.); hillside, Tolland, alt. 2680 m., 19 July, 1917, *Clokey 2853* (I. W. Clokey Herb. and Mo. Bot. Gard. Herb.); mountain side, Glacier Lake, alt. 2770 m., 26 Aug., 1917, *Clokey 2941, 2954* (I. W. Clokey Herb. and Mo. Bot. Gard. Herb.); dry hillsides, Ward, alt. 2865 m., 13 Aug., 1916, *Clokey 2711* (I. W. Clokey Herb. and Mo. Bot. Gard. Herb.); Seven Lakes, alt. 3050 m., 9 Aug., 1884, *Letterman* (Mo. Bot. Gard. Herb.); Golden, 13 July, 1885, *Letterman 55, 85* (Mo. Bot. Gard.

Herb.); head-waters of Clear Creek, and alpine ridges lying east of Middle Park, coll. of 1861, *Parry 19* (Gray Herb., Mo. Bot. Gard. Herb., and Phil. Acad. Nat. Sci. Herb.), and *Parry 22* (Gray Herb. and Mo. Bot. Gard. Herb.); Lat. 39–41°, coll. of 1862, *Hall & Harbour 333* in part (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); Rocky Mountains, Lat. 40–41°, Powell's Colo. Expl. Exp., 1868, *Vasey 340A* (Mo. Bot. Gard. Herb.); near Georgetown, 11 Aug., 1871, *Geo. Smith* (Phil. Acad. Nat. Sci. Herb.); wet mountain valley, base of Snowy Range, 24 July, 1872, *Redfield 503* (Mo. Bot. Gard. Herb.); Ute Pass, alt. 2740 m., Hayden's U. S. Geol. Survey, 4 July, 1873, *J. M. Coulter* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); Bear Creek, Hayden's U. S. Geol. Survey, 24 June, 1873, *J. M. Coulter* (U. S. Nat. Herb.); gravelly slopes of Spring Creek Valley, above Idaho, 31 July, 1874, top of Douglas Mountains, near Empire, alt. 2895 m., 2 Aug., 1874, moraines on Clear Creek, 25 Aug., 1874, and Ute Pass, Manitou Springs, 22 Sept., 1874, *Engelmann* (Mo. Bot. Gard. Herb.); without definite locality, Sept., 1874, *O. Kuntze* (U. S. Nat. Herb.); Manitou Trail to Pikes Peak, 13 Aug., 1884, *Letterman* (Mo. Bot. Gard. Herb.); region of Pikes Peak, 14 Aug., 1913, *Macbride 2670* (Mo. Bot. Gard. Herb.); mountain sides near Georgetown, July, 1885, *Patterson 79* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Ute Pass, alt. 2135 m., 21 July, 1886, *Trelease* (Mo. Bot. Gard. Herb.); Manitou, 16 Aug., 1886, *Fritchey* (Mo. Bot. Gard. Herb.); mountains above Manitou, alt. 2285 m., 27 May, 1892, *Crandall* (Mo. Bot. Gard. Herb.); Democrat, coll. of 1887, *Eleanor J. Pond* (U. S. Nat. Herb.); Georgetown, alt. 2590 m., 20 July, 1892, *Crandall* (Mo. Bot. Gard. Herb.); Upper Bear Creek, 24 July, 1889, *E. L. Greene* (Greene Herb., Univ. of Notre Dame, No. 47413); foothills, alt. 1980 m., 1 June, 1895, *Cowen 284* (U. S. Nat. Herb.); Georgetown, 17 Aug., 1895, *Shear 4517* (U. S. Nat. Herb.); Silver Plume, 21 Aug., 1895, *Shear 5000* (U. S. Nat. Herb.); Pikes Peak, 27 Aug., 1895, *Canby* (Gray Herb. and U. S. Nat. Herb.); above Beaver Creek, alt. 3050 m., 8 July, 1896, *Crandall 3090* (U. S. Nat. Herb.); on rocks in the aspen zone, Sil-

ver Plume, Clear Creek Cañon, alt. 3090 m., 19 Aug., 1896, *Holm* (Mo. Bot. Gard. Herb.); gulch, south of Rist Cañon, 15 June, 1898, *Crandall 3089* (Gray Herb.); Horsetooth Gulch, 7 June, 1899, *State Agr. Coll. Colo. 3083* (U. S. Nat. Herb.); Pikes Peak, 10 July, 1901, *Williamson* (Phil. Acad. Nat. Sci. Herb. and C. S. Williamson Herb.); Dark Cañon, alt. 2900 m., 19 July, 1901, *F. E. & E. S. Clements 109* (Gray Herb., Mo. Bot. Gard. Herb., and U. S. Nat. Herb.); Bottomless Pit, alt. 3850 m., 6 Aug., 1901, *F. E. & E. S. Clements 522* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); slopes of Cheyenne Mountain, Colorado Springs, 20 June, 1912, *Churchill* (J. R. Churchill Herb. and Mo. Bot. Gard. Herb.); Pikes Peak, 19 and 25 Aug., 1915, *Drushel* (J. A. Drushel Herb. and Mo. Bot. Gard. Herb.); Palmer Lake, 28 Aug., 1915, *Drushel* (J. A. Drushel Herb.); near Breckenridge, alt. 2895 m., Aug., 1901, *Mackenzie 238* (Phil. Acad. Nat. Sci. Herb.); Wolcott, Eagle Co., 11 July, 1902, *Osterhout 2667* (Gray Herb.); Twin Lakes, Wheeler's Exp., 1873, *Wolf & Rothrock 557* (Gray Herb. and U. S. Nat. Herb.); mountains of Colorado, coll. of 1870, *E. L. Greene 227* (Gray Herb.); gravelly places, South Cottonwood Gulch, Chaffee Co., alt. 2895 m., 9 and 29 July, 1892, *Sheldon 165, 167, 486* (U. S. Nat. Herb.); Sangre de Cristo Mountains, Aug., 1874, *Brandegee 942* (Mo. Bot. Gard. Herb.); Mt. Ouray, region of Gunnison Watershed, alt. 3810 m., 20 Aug., 1901, *C. F. Baker 857* (Gray Herb., U. S. Nat. Herb., Greene Herb., Univ. of Notre Dame, and Mo. Bot. Gard. Herb.); dry hills, vicinity of Trinidad, alt. 1800–1950 m., 17 July, 1911, *Standley 6025* (U. S. Nat. Herb.); hills west of Trinidad, 14 June, 1917, *Johnston & Hedgcock 153* (Mo. Bot. Gard. Herb.); Mancos, July, 1890, *Eastwood* (U. S. Nat. Herb.); without definite locality, *Dapprich* (Pub. Mus. Milwaukee Herb. No. 8833).

New Mexico: uplands, Upper Canadian Valley, Catskill, coll. of 1895, *Mrs. O. St. John 71* (Gray Herb.); Baldy, 14 Aug., 1910, *Wooton* (U. S. Nat. Herb.); Rio Pueblo, 10 Aug., 1910, *Wooton* (U. S. Nat. Herb.); Jemez Mountains, alt. 3350 m., 4 Sept., 1906, *Vernon Bailey 1023* (U. S. Nat. Herb.); Pecos River, July, 1898, *G. E. Coghill 101* (Mo. Bot. Gard. Herb.);

Winsor's Ranch, Pecos River National Forest, alt. 3655 m., 13 July, 1908, *Standley 4351* (U. S. Nat. Herb., C. C. Deam Herb., and Mo. Bot. Gard. Herb.); Las Vegas, July, 1881, *Vasey* (U. S. Nat. Herb. and Greene Herb., Univ. of Notre Dame); Las Vegas, 23 and 24 June, 1891, *Dewey* (U. S. Nat. Herb.); foot of mountains along Santa Fé Creek, twelve miles above Santa Fé, June and July, 1847, *Fendler 478, 480* [*444*] (Gray Herb., Berlin Herb., U. S. Nat. Herb., Torr. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.), TYPE; Sandia Mountains, Whipple's Expl. for a Railway Route from the Mississippi River to the Pacific Ocean, 10 Oct., 1853, *Bigelow* (Gray Herb. and U. S. Nat. Herb.); Santa Fé Cañon, alt. 2435 m., 26 June, 1897, *A. A. & E. G. Heller 3774* (Gray Herb., Greene Herb., Univ. of Notre Dame, U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Santa Fé Cañon, 3 Oct., 1913, *Rose, Fitch & Parkhurst 17754* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Santa Fé Cañon, 6 Aug., 1910, *Wooton* (U. S. Nat. Herb.); among rocks and bushes, Sandia Mountains, July and Aug., 1914, *Miss Charlotte C. Ellis 342* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Sandia Mountains, 4 Aug., 1910, *Wooton* (U. S. Nat. Herb.); El Capitan Mountains, alt. 2285 m., 28 July, 1910, *Baker, Earle & Tracy 208* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Mescalero Reservation, White Mountains, 21 July, 1905, *Wooton* (U. S. Nat. Herb.); Wills Cañon, Sacramento Mountains, 20 Aug., 1901, *Wooton* (U. S. Nat. Herb.); James Cañon, Sacramento Mountains, 6 Aug., 1905, *Wooton* (U. S. Nat. Herb., Mo. Bot. Gard. Herb., and Univ. Ariz. Herb.).

(?) Kansas: without locality, *Prof. Snow* (U. S. Nat. Herb. No. 49321).

Var. **molestus** Greenm. var. nov.

Stems 2 to 3.5 dm. high, branched, sparingly floccose-tomentulose; basal and lower stem-leaves obovate to oblanceolate, including the petiole 2 to 9 cm. long, .5 to 2 cm. broad, rounded to submucronate at the apex, crenate-dentate to subentire, at first slightly tomentose, soon becoming glabrous or nearly so; uppermost stem-leaves similar, sessile, dentate or

entire; inflorescence and characters of the head like the species.

Specimens examined:

Colorado: Lat. 39–41°, coll. of 1862, *Hall & Harbour 333* in part (Gray Herb. and Field Mus. Herb.), TYPE; mountain sides near Georgetown, alt. 2435–3050 m., *Patterson 79* in part (Gray Herb.); Silverton, July, 1889, *Eastwood* (U. S. Nat. Herb. No. 215761).

An extreme form differing from the type of the species in becoming nearly glabrous, and in having merely sinuate-dentate to entire leaves. Numerous intermediate forms occur, such as Sheldon's No. 167, which connect the variety with the species.

Var. **canovirens** (Rydb.) Greenm. comb. nov.

Senecio canovirens Rydb. Bull. Torr. Bot. Club **27**: 187. 1900.

Leaves oblanceolate, 2 to 15 cm. long, .5 to 2.5 cm. broad, subentire to sinuately lobed or even coarsely and unequally toothed.

Distribution: Pikes Peak, Colorado, to southern New Mexico.

Specimens examined:

Colorado: Pikes Peak, 25 Aug., 1915, *Drushel* (J. A. Drushel Herb. and Mo. Bot. Gard. Herb.); summit of wet mountains, Fremont Co., alt. 2730 m., 28 Sept., 1910, *Eggleston 6335* (U. S. Nat. Herb.).

New Mexico: White Mountains, Lincoln Co., alt. 2740 m., 30 July, 1897, *Wooton 244* (U. S. Nat. Herb., Gray Herb., Berlin Herb., Greene Herb., Univ. of Notre Dame, and Mo. Bot. Gard. Herb.); craters, Valencia Co., 28 July, 1906, *Wooton* (U. S. Nat. Herb.); Water Cañon, Magdalena Mountains, Socorro Co., 16 July, 1897, *C. L. Herrick 746* (U. S. Nat. Herb.); hillsides, Black Range, coll. of 1904, *Metcalfe 1179* (U. S. Nat. Herb.); Organ Mountains, Dona Ana Co., alt. 2740 m., 4 Sept., 1897, *Wooton 493* (Mo. Bot. Gard. Herb. and Greene Herb., Univ. of Notre Dame, No. 47404).

The frequently elongated and coarsely toothed leaves on certain specimens give to this variety a very different aspect than is presented by typical specimens of *S. Fendleri*; but the variety appears to pass imperceptibly into the species through several of the specimens above cited, particularly Baker, Earle and Tracy's No. 208, and Wooton's collections from the White Mountains and the Sacramento Mountains. A striking characteristic of the species, as well as the variety, is shown on many of the carefully collected specimens, namely, the presence of short offshoots or more frequently elongated slender stolons which bear leaves from entire to sinuately lobed or even subbipinnate. This character is well shown by Fendler's No. 478 in the Royal Herbarium at Berlin and by Patterson's No. 79 in several American herbaria. The foliage of the species is extremely variable, but the characters of the inflorescence and heads are relatively constant. The two specimens, namely, Fendler's No. 478 and 480, on which Dr. Gray based the species, present a rather different appearance in leaf character, particularly the extent to which the leaves are divided; nevertheless, in the light of a large suite of specimens there can be no doubt but that Dr. Gray was perfectly right in regarding the two Fendler plants as conspecific; and furthermore the species seems to be even more inclusive than originally defined.

106. S. Muirii Greenm.[1]

S. aureus var. *borealis* Gray, Bot. Calif. **1**: 412. 1876; Syn. Fl. N. Am. **1**[2]: 391. 1884, and ed. 2, 1886, in part, not Torr. & Gray.

S. werneriaefolius Coville, Contr. U. S. Nat. Herb. **4**: 140. 1893, not Gray.

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[1] **Senecio Muirii** Greenm. sp. nov., herbaceus perennis juventate ubique floccoso-tomentulosus plus minusve glabratus; caulibus solitariis vel pluribus a caudice multicipiti 5–10 cm. altis; foliis inferioribus subcoriaceis elliptico-ovatis vel spatulato-linearibus 1.5–5 cm. longis 1.5–10 mm. latis obtusis vel submucronato-acutis integris vel ad apicem paulo dentatis; foliis superioribus multo reductis bracteiformibus; capitulis solitariis vel in corymboso-cymosis paucicipitibus dispositis 6–10 mm. altis radiatis; involucro campanulato parce calyculato tomentuloso vel subglabrato; involucri squamis circiter 21 lineari-lanceolatis 6–8 mm. longis et basi petioli marginati saepe purpurascentibus; flosculis liguliferis 8–12, ligulis flavis; floribus disci 35–60; achaeniis glabris.—Collected on Mount Dana, California, alt. 3050–3655 m., Geol. Surv. Calif., 28 and 29 June, 1863, *Brewer 1734, 1750* (Gray Herb. and U. S. Nat. Herb.), TYPE.

A low herbaceous perennial, floccose-tomentulose when young, more or less glabrate; stems solitary or several from a multicipital caudex, 5 to 10 cm. high; leaves mostly basal, thick and firm in texture, elliptic-ovate to spatulate-linear, 1.5 to 5 cm. long, 1.5 to 10 mm. broad, obtuse to submucronate-acute, entire or slightly dentate towards the apex; upper stem-leaves reduced to bracts; heads solitary or disposed in a few-headed corymbose cyme, 6 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate, tomentulose to nearly glabrous; bracts of the involucre about 21, linear-lanceolate, 6 to 8 mm. long and, as well as the base of the margined petioles, often tinged with purple; ray-flowers 8 to 12, rays yellow; disk-flowers 35 to 60; achenes glabrous.

Distribution: Sierra Nevada Mountains.

Specimens examined:

California: Mt. Dana, alt. 3050–3655 m., 28 and 29 June, 1863, *Brewer 1734, 1750* (Gray Herb. and U. S. Nat. Herb.), TYPE; Mt. Dana, alt. 3655 m., coll. of 1863, *Brewer 2689, 2690* (Gray Herb. and U. S. Nat. Herb.); near Sonora Pass, alt. 3500 m., coll. of 1863, *Brewer 1904* (Gray Herb. and U. S. Nat. Herb.); Sierra Nevada, coll. of 1875, *John Muir 4450* (Mo. Bot. Gard. Herb.); near Whitney Meadows, Sierra Nevada, Death Valley Expedition, 20 Aug., 1891, *Coville & Funston 1662* (U. S. Nat. Herb.); near Mt. Whitney, Sierra Nevada, Death Valley Expedition, 1 Sept., 1891, *Vernon Bailey* [*Coville & Funston*] *2052* (U. S. Nat. Herb.); Mono Co., 2 Aug., 1894, *Congdon 168* (Gray Herb.); Mt. Whitney, alt. 3960 m., 17 Aug., 1899, *E. B. Copeland 51* (U. S. Nat. Herb.); on Mt. Conness, 4 Aug., 1890, *Dr. Davidson* (Greene Herb., Univ. of Notre Dame, No. 48089).

107. S. saxosus Klatt, Anal. Naturhist. Hofmus. Wien **9**: 366. 1894; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902; Blankinship, Mont. Agr. Coll. Sci. Studies **1**: 103. 1904; Greenm. Ann. Mo. Bot. Gard. **2**: *pl. 20, fig. 2.* 1915.

S. petraeus Klatt, Abh. Natur. Gesell. Halle **15**: 330. 1881, not Boiss. & Reuter; Gray, Proc. Am. Acad. **19**: 54. 1883;

Syn. Fl. N. Am. 1²: 389. 1884, and ed. 2, 1886, mainly; Coulter, Manual Rocky Mountain Region, 210. 1885, mainly; Clements & Clements, Rocky Mountain Flowers, 293. 1914.

S. petrophilus Greene, Pittonia **3** : 171. 1897, not Klatt.

S. petrocallis Greene, Pittonia **4** : 116. 1900; Rydb. Fl. Colo. 397. 1906.

S. alpicola Rydb. Mem. N. Y. Bot. Gard. **1** : 447. 1900.

S. pentodontus Greene, Pl. Baker. **3** : 26. 1901.

(?) *S. turbinatus* Rydb. Bull. Torr. Bot. Club **33** : 159. 1906.

S. aureus var. *alpinus* Gray, Am. Jour. Sci. III. **33** : 240. 1862; Proc. Acad. Nat. Sci. Phil. p. 68. 1863; Porter & Coulter, Fl. Colo. 81. 1874.

A low herbaceous perennial, white-tomentulose in the early stages, more or less glabrate; stems solitary or cespitose from a multicipital caudex, .5 to 1.5 dm. high; leaves chiefly basal, rotund-obovate to spatulate, including the petiole 1.5 to 10 cm. long, .5 to 2 cm. broad, entire or crenate-dentate towards the apex; upper stem-leaves few, much reduced, bracteiform; inflorescence a terminal few to several-headed corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre (13–)21, linear-lanceolate, acute, 7 to 10 mm. long; ray-flowers 10 to 12, rays yellow; disk-flowers numerous, 35 to 75; achenes glabrous.

Distribution: Rocky Mountains at high altitudes, Montana and Idaho, south to Colorado.

Specimens examined:

Montana: Black Butte, Tobacco Root Range, alt. 3200 m., 11 Aug., 1902, *Blankinship* (Gray Herb.); Cedar Mountain, alt. 3150 m., 16 July, 1897, *Rydberg & Bessey 5269* (U. S. Nat. Herb.).

Idaho: Slide Rock, Mackay (Bear Cañon), Custer Co., alt. 3150 m., 31 July, 1911, *Nelson & Macbride 1509* (Mo. Bot. Gard. Herb.); Saw-tooth Peak, near Pettit Lake, 27 July, 1895, *Henderson 3528* (U. S. Nat. Herb.); summit of Soldier Mountains, alt. 3350 m., 15 July, 1895, *Henderson 3230* (U. S. Nat. Herb.); alpine summits on exposed rock slides, Parker Mountain, Custer Co., alt. 2740 m., 17 July, 1916, *Macbride & Payson 3262* (Mo. Bot. Gard. Herb.).

Yellowstone National Park: on a rocky slope near the summit, The Thunderer, 13 July, 1899, *A. & E. Nelson 5822* (Gray Herb. and Mo. Bot. Gard. Herb.).

Colorado: head-waters of Clear Creek, and the alpine ridges lying east of "Middle Park," coll. of 1861 and 1862, *Parry 63* (Gray Herb.); Lat. 39–41°, coll. of 1862, *Hall & Harbour 329* (Gray Herb., Phil. Acad. Nat. Sci. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.), TYPE; Lat. 39–41°, coll. of 1862, *Hall & Harbour 331* in part (U. S. Nat. Herb.); Mt. Parry, coll. of 1872, *Gray* (Gray Herb.); without definite locality or date, *Dr. Savell 11* (Gray Herb.); White House Mountain, alt. 3960 m., 9 Aug., 1873, *J. M. Coulter* (Phil. Acad. Nat. Sci. Herb.); Sangre de Cristo Range, Aug., 1873, *Brandegee 727* (Mo. Bot. Gard. Herb.); Pikes Peak, alt. 1825–2130 m., Aug., 1876, *C. Mohr* (U. S. Nat. Herb.); Sawatch Range, alt. 1830–2130 m., Aug., 1880, *Brandegee 9* (Gray Herb.); Gray's Peak, Aug., 1882, *Patterson & Beaty* (Mo. Bot. Gard. Herb.); Gray's Peak and vicinity, Aug., 1885, *Patterson 83* (Gray Herb. and Mo. Bot. Gard. Herb.); high mountains, alt. 2440–3655 m., coll. of 1893, *Purpus 462, 683, 693* (Univ. Chicago Herb. at Field Mus.); mountains above Boreas, alt. 3655 m., 2 Aug., 1895, *J. H. Cowen* (Mo. Bot. Gard. Herb.); foot of Gray's Peak, 23 Aug., 1895, *Shear 4634* (U. S. Nat. Herb.); Chicken Creek, west of Mt. Hesperus, alt. 3500 m., 13 July, 1898, *Baker, Earle & Tracy 589* (Mo. Bot. Gard. Herb.); Upper La Platte, 13 July, 1898, *Baker, Earle & Tracy 993* (Mo. Bot. Gard. Herb.); near Pagosa Peak, alt. 3500 m., 6 Aug., 1899, *Baker 714* (Berlin Herb. and Mo. Bot. Gard. Herb.); Carson, region of Gunnison Watershed, alt. 3500 m., 2 July, 1901, *Baker 309* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), *type* of *S. pentodontus;* mountains above Ouray, alt. 3050–3655 m., Aug., 1901, *Baker 770* (Gray Herb. and Mo. Bot. Gard. Herb.); near Breckenridge, Summit Co., alt. 3960 m., Aug., 1901, *Mackenzie 1* (Phil. Acad. Nat. Sci. Herb., Univ. Ariz. Herb., and Mo. Bot. Gard. Herb.); mountain side, Ida Bell Mine, Summit Co., alt. 3500 m., 8 Aug., 1917, *Clokey 2903* (I. W. Clokey Herb. and Mo. Bot. Gard. Herb.); Clover Mountain, above Garfield, alt.

3900 m., 31 July, 1910, *Eggleston 6069* (U. S. Nat. Herb.); dry open soil, Leadville, alt. 3960 m., 23 June, 1916, *Clokey 2691* (I. W. Clokey Herb. and Mo. Bot. Gard. Herb.).

Var. **toiyabensis** Greenm. var. nov.

Stems 2 to 10 cm. high; heads one or two, terminating the nearly naked scapose stem, discoid; achenes glabrous.

Distribution: mountains of northeastern Nevada and Idaho.

Specimens examined:

Nevada: Bunker Hill, Toiyabe Range, alt. 3350 m., 29 July, 1913, *P. B. Kennedy 4178* (Mo. Bot. Gard. Herb. Nos. 715463, 749546), TYPE; dry rocky hill, Bunker Hill, Toiyabe Forest, alt. 2250–3400 m., 29 July, 1913, *Hitchcock 861* (U. S. Nat. Herb. No. 766173).

Idaho: alpine meadows, mountain top, Lost River Mountains, near Clyde, Blaine Co., alt. 3045 m., 10 July, 1916, *Macbride & Payson 3131* (Mo. Bot. Gard. Herb.).

108. S. werneriæfolius Gray, Proc. Am. Acad. **19**: 54. 1883; Syn. Fl. N. Am. 1^2: 389. 1884, and ed. 2, 1886; Coulter, Manual Rocky Mountain Region, 209. 1885; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902; Rydb. Fl. Colo. 397. 1906; Clements & Clements, Rocky Mountain Flowers, 293. 1914, as *wernerifolius*.

S. aureus var. *werneriaefolius* Gray, Proc. Acad. Nat. Sci. Phil. p. 68. 1863; Porter & Coulter, Fl. Colo. 81. 1874.

S. perennans Nelson, Bull. Torr. Bot. Club **25**: 549. 1898, and Contr. Fl. Rocky Mountains, 43. 1904; Rydb. Fl. Colo. 397. 1906.

S. scaposus Nelson, Bull. Torr. Bot. Club **25**: 379. 1898, not DC.

A low herbaceous perennial, at first white-tomentose, more or less glabrate; stems solitary or several from a multicipital caudex, erect or nearly so, .5 to 2.5 dm. high; leaves chiefly basal, thick or subcoriaceous in texture, linear-spatulate to elliptic-oblanceolate, 2 to 10 cm. long, 2 to 15 mm. broad, entire or slightly dentate towards the apex, margins usually strongly revolute; inflorescence a terminal one to several-headed corymbose cyme; heads 10 to 12 mm. high, radiate;

involucre campanulate, sparingly calyculate, persistently tomentulose; bracts of the involucre (13–)21, linear-lanceolate, 6 to 8 mm. long; ray-flowers 10 to 12, rays yellow; disk-flowers numerous, 45 to 60; achenes glabrous or rarely slightly hirtellous.

Distribution: foothills and mountains, Wyoming and south-western South Dakota to Arizona.

Specimens examined:

Wyoming: Laramie Hills, 6 June, 1896, *A. Nelson 1908* (Gray Herb. and Mo. Bot. Gard. Herb.); Battle Lake Mountain, 17 Aug., 1897, *A. Nelson 4216* (Gray Herb. and Mo. Bot. Gard. Herb.); rocky ravine, Laramie Hills, Albany Co., 4 June, 1899, *A. & E. Nelson 6822* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); shaded cañons, Laramie Mountains, Albany Co., June, 1902, *A. Nelson 8832* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); near Laramie, 31 May, 1897, *Osterhout 30* (Greene Herb., Univ. of Notre Dame).

South Dakota: Hot Springs, June, 1893, *Schneck* (Mo. Bot. Gard. Herb.).

Colorado: Lat. 39–41°, coll. of 1862, *Hall & Harbour 331* (Gray Herb., Phil. Acad. Nat. Sci. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.), TYPE, erroneously recorded as No. 313 in original publication; Lat. 39–41°, coll. of 1862, *Hall & Harbour 321* (U. S. Nat. Herb. No. 40360); Rocky Mountains, coll. of 1862, *Parry* (Mo. Bot. Gard. Herb.); dry woods of pine and spruce at great elevations, 14 June, 1870, *E. L. Greene 224* (Gray Herb.); Gray's Peak, 30 July, 1872, *Redfield 194* (Mo. Bot. Gard. Herb.); Clear Creek Cañon, alt. 2740 m., Hayden's U. S. Geol. Survey, 15 June, 1873, *J. M. Coulter* (Gray Herb., U. S. Nat. Herb., and Phil. Acad. Nat. Sci. Herb.); Clear Creek, Hayden's U. S. Geol. Survey, 20 May, 1873, *J. M. Coulter* (Phil. Acad. Nat. Sci. Herb.); Georgetown, Wheeler's Expedition, June, 1873, *Wolf & Rothrock 588* [*172*] (Gray Herb. and U. S. Nat. Herb. No. 48767); Georgetown, coll. of 1875, *E. L. Greene* (Greene Herb., Univ. of Notre Dame); Georgetown Pass, near Empire, 5 Aug., 1874, *G. Engelmann* (Mo. Bot. Gard. Herb.); high mountains about Gray's Peak, alt. 3050–3655 m., July, 1885, *Patterson*

85 (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Gray's Peak, alt. 3350–3800 m., 23 July and 15 Aug., 1885, *Letterman* (Mo. Bot. Gard. Herb.); Breckenridge, coll. of 1887, *S. D. Bereman 750* (Mo. Bot. Gard. Herb.); Cripple Creek, alt. 3050 m., May, 1895, *Tweedy 356* (U. S. Nat. Herb.); Mount Baldy, alt. 3400 m., 20 June, 1903, *F. E. & E. S. Clements 298.1* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); St. Elmo, alt. 3030 m., 2 June, 1910, *Eggleston 5634* (U. S. Nat. Herb.); on dry hillsides, Tolland, alt. 2740 m., 21 June, 1914, *Overholts* (Mo. Bot. Gard. Herb.).

Utah: cañon above Tropic, alt. 2135 m., 29 May, 1894, *M. E. Jones 5312as* (U. S. Nat. Herb. No. 326831).

Arizona: San Francisco Mountains, alt. 2740 m., 25 June, 1891, *MacDougal 289* (U. S. Nat. Herb.); DeMotte Park, Buckskin Mountains, alt. 2740 m., 19 Sept., 1894, *M. E. Jones 6056al* (U. S. Nat. Herb. No. 326830); Humphrey's Peak, San Francisco Mountains, alt. 2740–3655 m., 7–10 Aug., 1898, *MacDougal 388* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Univ. Ariz. Herb.); Kendrick Peak, near Flagstaff, June, 1900, *Purpus 8002* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); slopes of San Francisco Mountains, alt. 3000 m., 7 July, 1901, *Leiberg 5661* (U. S. Nat. Herb.), form with both glabrous and slightly hirtellous achenes; San Francisco Mountains, May–Oct., 1902, *Purpus 26* (Mo. Bot. Gard. Herb.).

Var. **incertus** Greenm. var. nov.

Heads subdiscoid; outer cycle of flowers 8 to 12, tubular, somewhat smaller than the normal flowers of the disk, their corollas slender, 3–4-toothed, and bearing imperfect stamens.

Distribution: known only from the type locality.

Specimen examined:

Colorado: Georgetown, coll. of 1875, *E. L. Greene* (Gray Herb.), TYPE.

109. S. Thurberi Gray, Proc. Acad. Nat. Sci. Phil. p. 68. 1863; Syn. Fl. N. Am. **1**^{2}: 389. 1884, and ed. 2, 1886; Greenm.

Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902; Wooton & Standley, Contr. U. S. Nat. Herb. **19** : 746. 1915.

S. canus var. *pygmaea* Gray, Bot. Mex. Bound. Surv. p. 103. 1859.

A low herbaceous perennial, at first white-tomentose, somewhat glabrate; stems solitary or cespitose, .5 to 1.5 dm. high, slender; leaves chiefly basal, linear or linear-oblanceolate, 1 to 3 cm. long, 1 to 2 mm. broad, entire or inconspicuously dentate towards the apex, acute or obtusish, slightly revolute-margined; upper stem-leaves few, bract-like; heads solitary or terminating the scapose stem in a few-headed corymbose cyme, 6 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate, glabrous or nearly so; bracts of the involucre (13–)21, linear-lanceolate, 4 to 7 mm. long; ray-flowers 7 to 10, rays yellow; disk-flowers rather numerous; achenes hispidulous.

Distribution: mountains of southwestern New Mexico.

Specimens examined:

New Mexico: hillsides, Copper Mines, Santa Rita del Cobre, May, 1851, *Thurber 210* (Gray Herb., Kew Herb., Berlin Herb., and Mo. Bot. Gard. Herb.), TYPE, and at the same station, June, 1851, *Bigelow* (Gray Herb.); without definite locality, *Mexican Boundary Survey 661* (U. S. Nat. Herb. Nos. 47599, 47600).

110. S. Actinella Greene, Bull. Torr. Bot. Club **10** : 87. 1883; Gray, Syn. Fl. N. Am. **1**^{2}: 384. 1884, and ed. 2, 1886; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902; Wooton & Standley, Contr. U. S. Nat. Herb. **19** : 745. 1915.

A low herbaceous perennial, at first white-tomentose throughout, more or less glabrate; stem 1 to 3 dm. high, rising from a stoutish subhorizontal or ascending rootstock, leafy at the slightly decumbent base, nearly naked above; leaves subcoriaceous, ovate, obovate to oblong-oblanceolate, rounded to obtuse at the apex, entire to slightly sinuate-dentate, narrowed below into a winged petiole, including the petiole 1.5

to 10 cm. long, .5 to 2.5 cm. broad; heads usually solitary, rarely two, 1.5 to 2 cm. high, radiate; involucre campanulate, calyculate; bracts of the involucre about 21, linear-lanceolate, 10 to 13 mm. long; ray-flowers 9 to 13, rays pale yellow; disk-flowers numerous; achenes pubescent.

Distribution: southwestern United States and northern Mexico.

Specimens examined:

Arizona: Flagstaff, 7 June, 1883, *Rusby 671* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.), TYPE; without definite locality, coll. of 1869, *E. Palmer* (Kew Herb. and U. S. Nat. Herb.); San Francisco Mountains, Aug., 1884, *Lemmon 3265* (Gray Herb. and U. S. Nat. Herb.); Baker's Butte, 2 June, 1890, *Jones* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Willow Spring, 10–20 June, 1890, *E. Palmer 488* (Gray Herb., Kew Herb., and U. S. Nat. Herb.); Flagstaff, 3 July, 1892, *Wooton* (U. S. Nat. Herb.); Belmont, 29 June, 1892, *Toumey 600* (Gray Herb.); Belmont, 29 June, 1892, *Toumey 600a* (U. S. Nat. Herb.); San Francisco Mountains, 14 July, 1892, *Toumey 600b* (U. S. Nat. Herb.); vicinity of Flagstaff, alt. 1675 m., 31 May, 1898, *MacDougal 5* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Univ. Ariz. Herb.); base of San Francisco Mountains, southwest side, 3 June, 1901, *Ward* (U. S. Nat. Herb.); near Flagstaff, alt. 1900 m., coll. of 1901, *Leiberg 5533* (U. S. Nat. Herb.); Fort Valley, Coconino National Forest and vicinity, 14 June, 1909, *Pearson 174* (U. S. Nat. Herb.); open flats, Cooley's Ranch, 1 July, 1912, *Goodding 1104* (U. S. Nat. Herb.).

Chihuahua: near Colonia Garcia in the Sierra Madre, alt. 2285 m., 9 June, 1899, *Townsend & Barber 25* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); vicinity of Madera, alt. about 2250 m., 27 May–3 June, 1908, *E. Palmer 282* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Durango: Quebrada Honda, 20 and 21 May, 1906, *E. Palmer 212* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), and *218* (Gray Herb. and U. S. Nat. Herb.).

Var. **mogollonicus** (Greene) Greenm. comb. nov.

S. mogollonicus Greene, Leafl. Bot. Obs. & Crit. **1**: 212. 1906; Wooton & Standley, Contr. U. S. Nat. Herb. **19**: 745. 1915.

Stem 2 to 4.5 dm. high; leaves spatulate-oblanceolate, 3 to 17 cm. long, .5 to 3.5 cm. broad; heads solitary or not infrequently two.

Distribution: New Mexico to northern Mexico.

Specimens examined:

New Mexico: Mogollon Mountains, on or near the West Fork of the Gila River, Socorro Co., alt. 2285 m., 7 Aug., 1903, *Metcalfe 410* (Greene Herb., Univ. of Notre Dame, U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), TYPE.

Arizona: Flagstaff, 14 May, 1891, *MacDougal 75* (U. S. Nat. Herb.).

Chihuahua: Sierra Madre, 24 Sept., 1887, *Pringle 1537* (Gray Herb.).

The variety has somewhat larger leaves with more attenuated petioles and occasionally bears two heads, but in all essential characters it accords with the species into which it directly passes through several intermediates.

111. **S. molinarius** Greenm.[1]

An herbaceous perennial, white-tomentose throughout; stems simple, erect, about 1.5 dm. high from a simple or branched ascending stoutish rootstock, densely lanate at the base, floccose-tomentose above; leaves mostly clustered at the base of the stem, petiolate, subobovate to broadly elliptic, including the petiole 2 to 6 cm. long, .5 to 1.5 cm. broad, entire,

[1] **Senecio molinarius** Greenm. sp. nov., herbaceus perennis; rhizomate crasso ascendente simplici vel ramoso; caule simplici erecto circiter 1.5 dm. alto basi dense lanato superne floccoso-tomentoso; foliis inferioribus petiolatis subobovatis vel ellipticis petiolo incluso 2–6 cm. longis .5–1.5 cm. latis integris ad apicem submucronatis basi in petiolum angustatis subcoriaceis juventate utrinque albo-tomentosis denique plus minusve glabratis, petiolo lamina longiore; foliis superioribus paucis multo reductis bracteiformibus; inflorescentiis terminalibus crebre corymboso-cymosis paucicipitibus; capitulis circiter 12 mm. altis radiatis; involucro campanulato calyculato; involucri squamis plerumque 21 lineari-lanceolatis 7–8 mm. longis apice acutis purpurascentibus albo-marginatis dorso dense tomentulosis; flosculis liguliferis 10–12, ligulis flavibus; floribus disci circiter 60; achaeniis hirtellis.—Collected at Pagosa Springs, Colorado, alt. 2130 m., 15 May, 1894, *Benjamin H. Smith* (Phil. Acad. Nat. Sci. Herb., photograph in Mo. Bot. Gard. Herb.), TYPE. Mr. Smith's plant was distributed as "*Senecio canus* Hook.", under which name it may be found in herbaria.

submucronate, narrowed below into a petiole usually exceeding the blade, thick and firm in texture, white-tomentose on both surfaces, somewhat glabrate; inflorescence a few-headed close corymbose cyme; heads about 12 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre about 21, linear-lanceolate, 7 to 8 mm. long, densely tomentose, whitish-margined and conspicuously tipped with purple; ray-flowers 10 to 12, rays yellow; disk-flowers about 60; achenes hirtellous.

Distribution: known only from the type locality.

Specimen examined:

Colorado: Pagosa Springs, alt. 2130 m., 15 May, 1894, *Benjamin H. Smith* (Phil. Acad. Nat. Sci. Herb.), TYPE.

112. S. gerberaefolius Schz. Bip. in Hemsl. Biol. Cent.-Am. Bot. **2** : 240. 1881; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902.

A low herbaceous perennial; stem erect, scapose, 1 to 3 dm. high from a stout caudex, silky villous at the base, tomentose to nearly glabrous above; leaves mostly radical, subcoriaceous, lanceolate to oblong-lanceolate, including the narrowly winged silky villous petiole 5 to 14 cm. long, 1 to 2 cm. broad, acute or obtuse, entire or obscurely dentate, strongly revolute-margined, at first tomentulose but soon glabrate above, densely and permanently white-tomentose beneath; upper stem-leaves few, bract-like; heads 2 to 6, rather large, 13 to 17 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre about 13, lanceolate to lance-ovate, 10 to 13 mm. long, 1.5 to 4 mm. broad; ray-flowers about 13, rays yellow; disk-flowers numerous; achenes densely appressed-villous.

Distribution: high mountains of southern Mexico.

Specimens examined:

South Mexico: peak of Orizaba, alt. 3050–4660 m., *Liebmann 140* (Gray Herb.); rocky soil, subalpine region, Mt. Ixtaccihuatl, Oct., 1905, *Purpus 1516* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

113. S. Greenei Gray, Proc. Am. Acad. **10** : 75. 1874; Bot. Calif. **1** : 412. 1876; Syn. Fl. N. Am. **1**^{2}: 385. 1884, and ed. 2, 1886; Greene, Manual, Region of San Francisco Bay, 213. 1894; Fl. Franciscana, 472. 1897; Jepson, Fl. West. Mid. Calif. 512. 1901, and ed. 2, 428. 1911; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902.

An herbaceous perennial, at first lightly floccose-tomentulose, somewhat glabrate; stems 1.5 to 4 dm. high, erect or nearly so; lower leaves ovate, rarely lanceolate, including the petiole 3 to 12 cm. long, 1 to 6 cm. broad, rounded to acute at the apex, dentate to subentire, abruptly contracted to gradually narrowed at the base into the petiole, equalling or much exceeding the blade, rather thin in texture; upper stem-leaves few, much reduced, bract-like; heads few, 1 to 3, large, 1.5 to 2 cm. high; involucre campanulate, sparingly calyculate; bracts of the involucre about 21, linear-lanceolate, 10 to 13 mm. long; ray-flowers about 12, narrowly oblong, 12 to 20 mm. long, deep orange; disk-flowers numerous; achenes glabrous.

Distribution: Coast Range of northern California.

Specimens examined:

California: mountain side, near the Geysers, Lake Co., 17 June, 1874, *Greene 305* (Gray Herb.), TYPE; Lake Co., coll. of 1884, *Curran* (Kew Herb. and Phil. Acad. Nat. Sci. Herb.); Mt. St. Helena, 13 June, 1894, *E. L. Greene* (Greene Herb., Univ. of Notre Dame); between Mud Flats and Bennet Spring on the Newville-Covelo road in the Coast Range, Glenn Co., *Heller 11930* (Mo. Bot. Gard. Herb.); Sanhedrin Mountain, Mendocino Co., June, 1884, *Rattan 28* (Gray Herb. and Kew Herb.), form with lanceolate lower stem-leaves.

114. S. convallium Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902; Ann. Mo. Bot. Gard. **1** : 266. 1914.

An herbaceous perennial, subappressed-sericeous-pubescent; stems one to several from a common base, erect, 1.5 to 3 dm. high; basal and lower stem-leaves petiolate, elliptic-lanceolate to oblong-oblanceolate, including the petiole 2.5 to 6 cm. long, 5 to 12 mm. broad, entire or slightly dentate

towards the apex, subappressed-sericeous on both surfaces, somewhat glabrate above; upper stem-leaves much reduced, oblanceolate to linear, entire and bracteiform; inflorescence a few-headed corymbose cyme; heads about 1 cm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre about 13, linear-attenuate, 7 to 9 mm. long, acute, slightly sericeous-tomentulose; ray-flowers 8 to 10, rays yellow; disk-flowers 30 to 35; achenes glabrous.

Distribution: northern Utah.

Specimens examined:

Utah: Rabbit Valley, alt. 2130 m., U. S. Geol. and Geog. Survey of the Territories, Aug., 1875, *L. F. Ward 704* (Gray Herb., U. S. Nat. Herb., and Phil. Acad. Nat. Sci. Herb.), TYPE.

115. S. Leonardii Rydb. Bull. Torr. Bot. Club **37**: 468. 1910.

S. aureus var. *obovatus* Wats. Bot. King's Exp. 190. 1871, in part, i. e. as to Watson's Nos. 669, 668.

An herbaceous perennial, at first lightly floccose-tomentulose throughout, later more or less glabrate; stems erect, 3 to 7.5 dm. high, simple or branched, striate; basal and lower stem-leaves long-petiolate, ovate to obovate or oblong-oblanceolate, including the petiole 4 to 18 cm. long, 1 to 3 cm. broad, rounded to obtuse at the apex, crenate-dentate to rather sharply serrate, narrowed below into the petiole which usually much exceeds the blade, rather thickish in texture, lightly floccose-tomentulose on both surfaces in the early stages but soon more or less glabrate especially on the upper surface; uppermost stem-leaves sessile, oblanceolate to lanceolate, dentate to laciniate-pinnatifid, often semiamplexicaul by an expanded coarsely toothed base; inflorescence a terminal several to many-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, calyculate, floccose-tomentulose, especially at the base, to essentially glabrous; ray-flowers 10 to 13, rays yellow; disk-flowers rather numerous, 50 to 75; achenes glabrous.

Distribution: British Columbia, south to Utah and Nevada.

Specimens examined:

British Columbia: Burgess Trail, vicinity of Field, alt. 1520–1825 m., 16 July, 1906, *Stewardson Brown 510* (Phil. Acad. Nat. Sci. Herb.); Emerald Lake, Yoho Valley, 27 Aug., 1904, *Macoun* (Gray Herb. and Geol. Surv. Canada Herb. No. 65015).

Oregon: near top of Hasbrook Gulch, alt. 1520 m., 15 July, 1897, *Sheldon 8570* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Utah: Wasatch Mountains, alt. 2130 m., June, 1869, *Watson 669* (U. S. Nat. Herb.); Alta, Wasatch Mountains, alt. 3350 m., 31 July, 1879, *Jones 1125* (Berlin Herb., fragment and tracing in Gray Herb.); Salt Lake City, alt. 1310 m., 15 July, 1880, *Jones 1996* (U. S. Nat. Herb. and Univ. Chicago Herb. at Field Mus. No. 252611); near divide, head of American Fork Cañon, 29 July, 1885, *Leonard 143* (N. Y. Bot. Gard. Herb.), TYPE; near Midway, Wasatch Co., 6 July, 1905, *Carlton & Garrett 6701* (U. S. Nat. Herb.).

Nevada: East Humboldt Mountains, alt. 2740 m., Aug., 1868, *Watson 668* (Gray Herb.).

This species has many characters in common with the section *Aurei,* but on account of the more or less persistent white tomentum on the stem, in the inflorescence, and on the leaf-surface it is placed rather in the section *Tomentosi.*

116. S. tomentosus Michx. Fl. Bor. Am. **2**: 119. 1803; Ell. Sk. **2**: 329. 1824; Torr. & Gray, Fl. N. Am. **2**: 443. 1843, excl. var. β.; DC. Prodr. **6**: 433. 1837, mainly; Gray, Syn. Fl. N. Am. **1**^{2}: 390. 1884, and ed. 2, 1886; Chapman, Fl. Southern U. S. 245. 1860, and ed. 2, 1889; *ibid.* ed. 3, 266. 1897; Britton & Brown, Ill. Fl. **3**: 477, *fig. 4038.* 1898, and ed. 2, 543, *fig. 4622.* 1913; Bergen, Fl. Northern and Central States, 232. 1901; Britton, Manual, 1026. 1901, and ed. 2, 1905; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902; Small, Fl. Southeastern U. S. 1304. 1903, and ed. 2, 1913; Greenm. in Gray's Manual, ed. 7, 855. 1908.

Cineraria integrifolia β. minor Pursh, Fl. Am. Sept. **2**: 528. 1814, and ed. 2, 1816, in synonymy and as to Carolina plant.

S. Alabamensis Britton in Small, Fl. Southeastern U. S. 1305. 1903, and ed. 2, 1913.

An herbaceous perennial, more or less densely woolly-tomentose; stems erect, 2 to 6 dm. high, simple or branched; radical and lower stem-leaves petiolate, oblong-ovate to oblong-lanceolate, including the petiole 5 to 40 cm. long, 1 to 7 cm. broad, occasionally sublyrate, rounded to acute at the apex, subentire, crenate to somewhat serrate-dentate, cuneate to subcordate at the base, at first densely white-tomentose on both surfaces, later more or less glabrate; petioles sometimes much exceeding the blade; upper stem-leaves variable, sessile, oblong-lanceolate to linear-lanceolate, subpinnate to entire; inflorescence a terminal few to many-headed corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate, tomentose to glabrous; bracts of the involucre about 21, linear-lanceolate, 6 to 7 mm. long; ray-flowers about 13, rays yellow; disk-flowers 50 to 60; achenes hispidulous.

Distribution: southern New Jersey to Florida, west to Arkansas and Texas.

Specimens examined:

New Jersey: West Creek, Ocean Co., 22 July, 1907, *Long* (Phil. Acad. Nat. Sci. Herb.); Egg Harbor, Atlantic Co., 1 May, 1900, *Williamson* (C. S. Williamson Herb.); Landisville, *Gross* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.); Dias Creek, 11 Aug., 1909, *Long,* Green Creek, 15 Aug., 1909, *Van Pelt,* Cold Spring, 27 May, 1906, *H. A. Lang,* Cold Spring, 1 June, 1911, *O. H. Brown,* 7 June and 13 Aug., 1907, *Van Pelt,* between Cape May and Cold Spring, 27 May, 1906, *Van Pelt,* Cape May, 31 May, 1885, *Isaac Burk,* Cape May, 15 June, 1892, *Joseph Crawford,* Cape May, 1 June, 1902, *W. Stone,* Cape May Court House, 1 June, 1912, *Williamson,* border of marsh, Cape May, 3 April, 1909, *Long,* Cape May Point, 27 May, 1906, *Van Pelt* (Phil. Acad. Nat. Sci. Herb.).

Delaware: Deakyneville, 27 July, 1891, *Commons* (Phil. Acad. Nat. Sci. Herb.); Ellendale, without date, *Williamson* (C. S. Williamson Herb.); Georgetown, 4 July, 1908, *William-*

son (Phil. Acad. Nat. Sci. Herb.); Gumboro, 4 Aug., 1874, *Commons* (Phil. Acad. Nat. Sci. Herb.); Frankford, 18 June, 1875, *Commons* (Phil. Acad. Nat. Sci. Herb.); sandy swamp, Millsboro, 23 May, 1876, *Commons* (Phil. Acad. Nat. Sci. Herb. and Mo. Bot. Gard. Herb.); Laurel, 16 June, 1893, and 30 May, 1895, *Commons* (Phil. Acad. Nat. Sci. Herb.); sandy soil, south Delaware, Aug., 1878, *Canby* (Phil. Acad. Nat. Sci. Herb.).

Maryland: Newhope, Wicomico Co., 10 May, 1905, *A. Hames 532* (U. S. Nat. Herb.); Berlin, Worcester Co., May, 1868, *Canby* (Mo. Bot. Gard. Herb.); without definite locality, *Pickering* (Phil. Acad. Nat. Sci. Herb.).

Virginia: low ground, Hampton, Elizabeth City Co., 13 May, 1877, *Ward* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); dry open field, Hampton, 19 May, 1903, *Miller* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); open field, Hampton, 26 April, 1913, *Standley & Bollman 9959* (U. S. Nat. Herb.); near Virginia Beach, Princess Co., 29 April, 1898, *Coville & Kearney 26* (U. S. Nat. Herb.); Norfolk, Norfolk Co., coll. of 1870, *J. McMinn* (U. S. Nat. Herb.); Norfolk, 15 May, 1872, *A. H. Curtiss* (Mo. Bot. Gard. Herb.); vicinity of Norfolk, coll. of 1907, *Jensen* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Norfolk, without date, *Dana* (Gray Herb.); Northwest, Norfolk Co., 23 May, 1893, *Heller 850* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); dry open ground, borders of Dismal Swamp, 15 May, 1877, *Morong* (Mo. Bot. Gard. Herb.); Dismal Swamp, coll. of 1877, *Chickering* (U. S. Nat. Herb.); Dismal Swamp, coll. of 1873, *W. H. Seaman* (U. S. Nat. Herb.); Suffolk, Nansemond Co., 8–13 June, 1893, *Heller 850* (Mo. Bot. Gard. Herb.); near Suffolk, 30 April, 1898, *Coville & Kearney 46* (U. S. Nat. Herb.); near Franklin, Isle of Wight Co., 7–28 June, 1893, *Heller 850* (Gray Herb.); near Branchville, Southampton Co., 12 June, 1893, *Heller 958* (U. S. Nat. Herb.).

North Carolina: Weldon, Halifax Co., colls. of 1892, 1897, and 1908, *Williamson* (Phil. Acad. Nat. Sci. Herb. and C. S. Williamson Herb.); without definite locality, *M. A. Curtis* (Mo. Bot. Gard. Herb.); Caesar's Head, 3 Sept., 1876, *Engelmann* (Mo. Bot. Gard. Herb.).

South Carolina: foot of Caesar's Head, coll of 1876, *A. Gray* (Gray Herb.); Table Rock, *Buckley* (Gray Herb.); mountains of Carolina, coll. of 1843–44, *Buckley* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.).

Georgia: Stone Mountain, May, 1883, *Engelmann* (Mo. Bot. Gard. Herb.); lower slopes of Stone Mountain, alt. 300–375 m., 17 April, 1893, *Small* (Phil. Acad. Nat. Sci. Herb. and Mo. Bot. Gard. Herb.); Stone Mountain, 14 May, 1897, *Biltmore Herb. 3134a* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Stone Mountain, 20 and 23 May, 1897, *Eggert* (Mo. Bot. Gard. Herb.); base of Stone Mountain, 11 April, 1901, *Biltmore Herb. 3134b* (C. C. Deam Herb.); lower slopes of Stone Mountain, 6 May, 1901, *A. H. Curtiss 6769* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); "Vidalia," April, 1914, *A. M. Huger* (Mo. Bot. Gard. Herb.).

Florida: damp pine barrens, without definite locality, *A. W. Chapman* (Gray Herb., Kew Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

Louisiana: banks of Red River, near Alexandria, *Hale* (U. S. Nat. Herb. and Kew Herb.).

Arkansas: without definite locality, *Nuttall* (Phil. Acad. Nat. Sci. Herb.); on prairie, Prescott, 8 April, 1900, *Bush 528* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Fulton, 30 April, 1905, *Bush 2519* (Mo. Bot. Gard. Herb.); low wet woods, Texarkana, 8 April, 1905, *Bush 2255* (Mo. Bot. Gard. Herb.).

117. S. antennariifolius Britton in Britton & Brown, Ill. Fl. **3**: 478, *fig. 4040*. 1898, and in ed. 2, 542, *fig. 4620*. 1913; Britton, Manual, 1027. 1901, and ed. 2, 1905; Greenm. Monogr. Senecio, I. Teil, 24. 1901, in Engl. Bot. Jahrb. **32**: 20. 1902, and in Gray's Manual, ed. 7, 855. 1908.

S. tomentosus var. β. Torr. & Gray, Fl. N. Am. **2**: 443. 1843.

Cineraria heterophylla Pursh, Fl. Am. Sept. **2**: 528. 1814, and ed. 2, 1816.

Senecio integrifolius β. *heterophylla* Nutt. Gen. **2**: 165. 1818.

An herbaceous perennial, more or less white-tomentose throughout; stems 2.5 to 4 dm. high; leaves mostly basal, oblong-obovate to spatulate, including the petiole 3 to 6 cm. long, .5 to 2 cm. broad, rounded or obtuse at the apex, entire to remotely and shallowly dentate, narrowed below the middle into the petiole, finely and densely matted white-tomentose beneath, loosely floccose-tomentose and somewhat glabrate above; stem-leaves sublyrate to merely dentate, the uppermost reduced to linear bracts; inflorescence a few to several-headed corymbose cyme; heads about 1 cm. high, radiate; involucre campanulate, calyculate, tomentulose; bracts of the involucre 18 to 21; ray-flowers 10 to 12, rays yellow; disk-flowers about 40; achenes hirtellous.

Distribution: mountains of Virginia.

Specimens examined:

Virginia: Blue Ridge, *Buckley* (Gray Herb.); Massanutton Mountains, Page Co., 13 May, 1900, *G. S. Miller* (U. S. Nat. Herb.); Hot Springs, 17 April, 1903, *C. F. Batchelder* (Walter Deane Herb., photograph in Field Mus. Herb. and in Mo. Bot. Gard. Herb.); Natural Bridge, 31 May, 1909, *Bartram & Long* (C. S. Williamson Herb.).

118. S. canus Hook. Fl. Bor. Am. **1**: 333, *pl. 116*. 1834; DC. Prodr. **6**: 433. 1837; Torr. & Gray, Fl. N. Am. **2**: 443. 1843, in part; Gray, Syn. Fl. N. Am. **1**^{2}: 390. 1884, and ed. 2, 1886, in part; Macoun, Cat. Canadian Pl. 266. 1884, and ed. 2, 555. 1886, in part; Coulter, Manual Rocky Mountain Region, 210. 1885, in part; Rydb. Contr. U. S. Nat. Herb. **3**: 510. 1896, and Mem. N. Y. Bot. Gard. **1**: 444. 1900, in part; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 580. 1909, in part (excl. synonymy); Fl. Intermountain States, 175. 1912, in part.

S. integrifolius Nutt. Gen. **2**: 165. 1818, in part.

S. Purshianus Nutt. Trans. Am. Phil. Soc. N. S. **7**: 412. 1841, in part, i. e. as to plant from "banks of the Missouri."

S. Purshianus var. *viridescens* Lunell, Am. Mid. Nat. **1**: 207. 1910.

S. canus var. *acraeus* Greenm. Ottawa Nat. **25** : 118. 1911.

S. canus var. *celsus* Sharp, Bot. Gaz. **61** : 46. 1916.

Cineraria integrifolia β. minor Pursh, Fl. Am. Sept. **2** : 528. 1814, and ed. 2, 1816, in part (excl. syn.), i. e. as to plant from "banks of the Missouri."

A cespitose herbaceous perennial, white-tomentose throughout, occasionally somewhat glabrate especially on the upper leaf-surface; stems erect or nearly so, simple or branched, usually about 3 dm. high (varying from 1.2 to 5 dm.); radical and lower stem-leaves oblong-obovate to oblanceolate, 2 to 12 cm. long, .5 to 2.5 cm. broad, rounded to obtuse at the apex, entire or somewhat dentate, usually persistently white-tomentose on both surfaces, occasionally more or less glabrate above, narrowed below the middle into a petiole about equalling or shorter than the blade; upper stem-leaves sessile, lanceolate to linear, entire to coarsely dentate, often ampliated and laciniate at the more or less amplexicaul base; inflorescence a terminal few to several-headed corymbose cyme; heads 10 to 12 mm. high, radiate or rarely discoid; involucre campanulate, sparingly calyculate, tomentose to nearly glabrous; bracts of the involucre usually about 21, occasionally fewer, linear-lanceolate, 6 to 8 mm. long; ray-flowers 8 to 12, rays yellow; disk-flowers commonly 40 to 70; achenes glabrous (notwithstanding original illustration).

Distribution: Manitoba to Nebraska, west to British Columbia and Colorado.

Specimens examined:

Dominion of Canada: "banks of the Saskatchewan," *Drummond* (Gray Herb. and Geol. Surv. Canada Herb.), CO-TYPE; Carlton House, *Richardson* (Geol. Surv. Canada Herb.); Palliser's Brit. N. Am. Expl. Exp., coll. of 1858, *Bourgeau* (Gray Herb.).

Manitoba: near Forest, 19 July, 1906, *Macoun* (Mo. Bot. Gard. Herb. and Geol. Surv. Canada Herb.).

Saskatchewan: Moose Mountains, July, 1880, and 4 July, 1883, *Macoun* (U. S. Nat. Herb. Nos. 219789, 143119); Assiniboine Rapids, 14 June, 1879, *Macoun 49* (Gray Herb.); Spy Hill, 23 June, 1879, *Macoun 52* (Gray Herb.), *type* of variety

acraeus, which, however, in a large series of specimens merges imperceptibly into the species; sand hills, along the Shell River, north of Prince Albert, 13 July, 1876, *Macoun* (Geol. Surv. Canada Herb. No. 12170); prairies, The Holes, Wood Mountain, 19 July, 1895, *Macoun* (Geol. Surv. Canada Herb. No. 11617); Frenchman's Creek, Cypress Hills, 22 June, 1895, *Macoun* (Geol. Surv. Canada Herb. No. 11618); on the dry side of a coulee, north of Moose Jaw, 22 June, 1896, *Macoun* (Geol. Surv. Canada Herb. No. 12789); on dry gravelly soil, near Moose Mountain Creek, 6 June, 1883, *Macoun* (Geol. Surv. Canada Herb. No. 14834), both radiate and discoid heads.

Alberta: on gravel, Police Point, Medicine Hat, 4 June, 1894, *Macoun 5069* (Gray Herb. and Geol. Surv. Canada Herb.); dry cliffs, Lethbridge, 5 June, 1894, *Macoun 5085* (Gray Herb., U. S. Nat. Herb., and Geol. Surv. Canada Herb.); Milk River, 8 July, 1881, *Dawson* (Geol. Surv. Canada Herb. No. 26687); dry slopes, Canmore, 29 June, 1885, *Macoun* (Geol. Surv. Canada Herb. No. 14827); on gravel along the railway, Calgary, 7 June, 1897, *Macoun* (Geol. Surv. Canada Herb. No. 23105); on the road around the Loop, near Banff, 28 June, 1899, *Dawson* (Geol. Surv. Canada Herb. No. 22317); on rocky slopes, Crow's Nest Pass, 5 Aug., 1897, *Macoun* (Geol. Surv. Canada Herb. No. 22789); dry gravelly slopes, Bow River at Morley, 6 Sept., 1879, *Macoun* (Geol. Surv. Canada Herb. No. 14833); near Banff, 26 June, 1891, *Macoun* (Gray Herb. and Mo. Bot. Gard. Herb.); near Banff, 25 July, 1895, *ex Herb. Canby* (Gray Herb. and U. S. Nat. Herb. No. 233908); gravelly and sandy slopes and plains, vicinity of Banff, alt. 1370 m., 28 June, 1899, *McCalla 2047* (U. S. Nat. Herb.); Banff, 4 Sept., 1903, also 3 and 14 June, 1904, *Farr* (Univ. Penn. Herb.); Bow River Valley, alt. 1370 m., 9–18 June, 1906, *Stewardson Brown 79* (Phil. Acad. Nat. Sci. Herb.); on the Brazeau River, 16 Sept., 1907, *Mrs. Chas. Schaffer* (Phil. Acad. Nat. Sci. Herb.); roadside, Banff, alt. 1340 m., 6 July, 1907, *Butters & Holway 53* (U. S. Nat. Herb.); Banff, 24 June, 1907, *Cowles 85* (Mo. Bot. Gard. Herb.); dry soil, Bow Valley west of Calgary, 7

June, 1913, *Moodie* (U. S. Nat. Herb.); dry grassy hills, vicinity of Rosedale, alt. 670–760 m., 28 May, 1915, *Moodie 917* (Mo. Bot. Gard. Herb.).

British Columbia: dry hillsides, Spences Bridge, Thompson River, 20 May, 1875, *Macoun* (Geol. Surv. Canada Herb. No. 14836); in dry gravelly soil, Milk River Ridge (Fossil Coulee), 22 June, 1883, *Dawson* (Geol. Surv. Canada Herb. No. 14835); dry slopes, Spences Bridge, 1 June, 1885, *Fletcher* (Geol. Surv. Canada Herb. No. 14830); dry slopes, Spences Bridge, 26 May, 1889, *Macoun* (Geol. Surv. Canada Herb. No. 14831); Canoe River, head-waters of Columbia River, 31 Aug., 1898, *Spreadborough* (Geol. Surv. Canada Herb. No. 19729); mountains at Kicking Horse Lake, alt. 1825 m., 12 Aug., and Kicking Horse River, alt. 1220 m., 13 Aug., 1890, *Macoun* (Gray Herb. and Geol. Surv. Canada Herb.); Burgess Trail, alt. 1525–1825 m., 16 July, 1906, *Stewardson Brown 512* (Phil. Acad. Nat. Sci. Herb.); Emerald Lake, Yoho Valley, 27 Aug., 1904, and Burgess Pass, Yoho Valley, alt. 2285 m., 28 Aug., 1904, *Macoun* (Gray Herb. and Geol. Surv. Canada Herb. Nos. 65010, 65009), reduced forms.

North Dakota: prairies near Leeds, 10 June, 1901, *Dr. J. Lunell* (C. S. Williamson Herb. and C. C. Deam Herb.); sunny hillsides, Butte, Benson Co., colls. of June, 1906, 1907, 1908, 1909, and July, 1909, *Dr. J. Lunell* (Greene Herb., Univ. of Notre Dame, Mo. Bot. Gard. Herb., and C. C. Deam Herb.); Minot, Ward Co., 6 June and 1 July, 1909, *Dr. J. Lunell* (Mo. Bot. Gard. Herb.); on prairies, Leeds, 10 June, 1902, and 5 July, 1907, *Dr. J. Lunell* (C. C. Deam Herb.), form with discoid heads; Butte, Benson Co., 10 July, 1909, *Dr. J. Lunell* (Mo. Bot. Gard. Herb.), form with discoid heads.

South Dakota: Black Hills, near Fort Meade, 16 May, 1887, *Forwood 229* (U. S. Nat. Herb.); Lead City, alt. 1525–1980 m., 4 July, 1892, *Rydberg 829, 830* (U. S. Nat. Herb.); Brookings, 31 July, 1908, *O. E. White* (Mo. Bot. Gard. Herb.); rocky hillsides, Deadwood, 19 July, 1913, *Rydberg 71* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Rapid Cañon, Pennington Co., 27 June, 1914, *W. H. Over 1667* (U. S. Nat. Herb.).

Nebraska: arid hills, Fort Union, July, 1853–1854, *Hayden* (Mo. Bot. Gard. Herb.); Bad Lands, coll. of 1853–1854, *Hayden* (Phil. Acad. Nat. Sci. Herb.); Eaglenest Butte, May, 1855, *Hayden* (Mo. Bot. Gard. Herb.); Scottsbluff, 24 July, 1891, *Rydberg 210* (U. S. Nat. Herb.).

"Banks of the Missouri": *M. Lewis*[1] (Phil. Acad. Nat. Sci. Herb.).

"Upper Louisiana": *Nuttall* (Phil. Acad. Nat. Sci. Herb.), form with discoid heads.

Montana: Mt. Helena, Helena, 30 June, 1883, *Canby 38*, and mountains near Bozeman, 4 July, 1883, *Canby 37* (Gray Herb.); Belt Creek, June, 1883, *F. W. Anderson 544* (U. S. Nat. Herb.); Great Falls, 13 July, 1885, *F. W. Anderson 780* (U. S. Nat. Herb.); Black Eagle Falls, Aug., 1889, *R. S. Williams* (Mont. Agr. Coll. Herb.); Park Co., coll. of 1889, *Tweedy* (U. S. Nat. Herb. No. 49284); near Butte, alt. 1675–1825 m., Aug., 1893, *Mrs. C. H. Moore* (Mo. Bot. Gard. Herb.); Anaconda, 7 July, and Granite, 14 July, 1892, *F. D. Kelsey* (Mont. Agr. Coll. Herb.); Little Belt Mountains, alt. 1830 m., 18 Aug., 1896, *J. H. Flodman 907* (Mo. Bot. Gard. Herb. and U. S. Nat. Herb.); Columbia Falls, 10 July, 1895, *R. S. Williams* (Mont. Agr. Coll. Herb.); cañons, Bozeman, 27 June, 1898, *Blankinship* (Gray Herb.); Kennedy Creek, 15 July, 1901, *Stuart Weller* (U. S. Nat. Herb. No. 411699); Deer Lodge, 15 July, 1901, *Mrs. E. W. Schuber 34* (Mont. Agr. Coll. Herb.); Midvale, 13 July, 1903, *Umbach 352, 359* (U. S. Nat. Herb.); Empire, June, 1902, *Owen Burns 147* (Mont. Agr. Coll. Herb.).

(?) Yellowstone National Park: "Yellowstone Exp.," 1873, *Allen* (U. S. Nat. Herb. No. 49282).

Wyoming: top of Bear Peak, 11 July, 1859, Big Horn Mountains, Aug., 1859, and Wind River Valley, 22 May, 1860, Raynolds' Exp. to the head-waters of the Missouri and Yellowstone Rivers, *Hayden* (Mo. Bot. Gard. Herb.); dry sandy soil, North Fork of Wind River, 15 July, 1882, *Forwood* (Gray Herb. and U. S. Nat. Herb. No. 317134); Wind River Crossings, 15 Aug., 1894, *A. Nelson 761* (Gray Herb. and U. S. Nat.

[1] See footnote under *Senecio Purshianus* Nutt.

Herb.); Pole Creek, 29 June, 1895, *A. Nelson 1364* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Green River, 1 June, 1897, *A. Nelson 3070* (Mont. Agr. Coll. Herb.); dry slopes, Seminole Mountains, Carbon Co., 21 July, 1898, *A. Nelson 4918* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Big Horn Mountains, alt. 2435 m., 1 Aug., 1898, *T. A. Williams* (U. S. Nat. Herb. No. 519669); Big Horn Mountains, Aug., 1898, *D. Griffiths* (Mo. Bot. Gard. Herb.); Shoshone Mountains, Aug., 1904, *H. Hapeman* (C. C. Deam Herb.).

Colorado: Cherokee Park, near Wyoming boundary line, 30 July, 1917, *Johnston & Hedgcock 160* (Mo. Bot. Gard. Herb.); high mountains, Gray's Peak and vicinity, July, 1885, *Patterson 80* in part (Gray Herb.).

119. S. Harbourii Rydb. Bull. Torr. Bot. Club **33**: 158. 1906; Fl. Colo. 396. 1906; Daniels, Univ. Mo. Studies, Sci. Ser. **2**: 399 [251]. 1911.

S. canus Porter & Coulter, Syn. Fl. Colo. 82. 1874, not Hook.; Coulter, Manual Rocky Mountain Region, 210. 1885, in part, not Hook.; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 580. 1909, in part, not Hook.

S. canus var. Rothrock, Bot. Wheeler Exp. 177. 1878, not *S. canus* Hook.

S. Rothrockii Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902.

A low cespitose herbaceous perennial, lightly floccose-tomentose throughout; stems ascending or suberect, 1 to 2.5 dm. high, simple or branched, usually leafy; basal and lower stem-leaves oblong-oblanceolate to narrowly oblanceolate, including the petiole 2 to 13 cm. long, 3 to 15 mm. broad, rounded to obtuse at the apex, entire or crenate-undulate, at first lightly floccose-tomentose on both surfaces, later somewhat glabrate, rather abruptly narrowed to gradually attenuated into a narrowly winged petiole, margins more or less revolute; upper stem-leaves usually conspicuous, lanceolate-ligulate and sessile by a more or less ampliated entire or dentate auriculate half-clasping base; inflorescence a terminal subcorymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanu-

late, sparingly calyculate, floccose-tomentulose to rarely glabrous; bracts of the involucre about 13, lanceolate, 7 to 10 mm. long; ray-flowers about 8, rays narrowly oblong, 10 to 12 mm. long, conspicuous; disk-flowers 30 to 40; achenes glabrous, 3 to 3.5 mm. long.

Distribution: mountains of Colorado.

Specimens examined:

Colorado: mountains south of Ward, Boulder Co., 18 July, 1901, *Osterhout 2424* (Phil. Acad. Nat. Sci. Herb.), CO-TYPE; head-waters of Clear Creek and the alpine ridges lying east of "Middle Park," coll. of 1861, *Parry 20* (Gray Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Lat. 39–41°, coll. of 1862, *Hall & Harbour 330* (Gray Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Mt. Parry, coll. of 1872, *Gray* (Gray Herb.); Union Pass, Wheeler's Exp., 1873, *Wolf & Rothrock 559* (Gray Herb. and U. S. Nat. Herb.); Mosquito Pass, Wheeler's Exp., 1873, *Wolf & Rothrock 585* (Gray Herb. and U. S. Nat. Herb.), *type* of *S. Rothrockii;* spur of Mt. Princeton, Aug., 1880, *Brandegee* (Mo. Bot. Gard. Herb.); alpine slopes above Berthoud's Pass, 22 July, 1881, *Engelmann* (Mo. Bot. Gard. Herb.); high mountains, Gray's Peak and vicinity, alt. 3350–4260 m., July, 1885, *Patterson 80* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

In some of the more reduced alpine forms this species resembles very closely *S. Purshianus,* but usually *S. Harbourii* is readily distinguished from that species by the leafy stem, larger heads, and longer involucral bracts and ray-flowers.

120. S. Purshianus Nutt.[1] Trans. Am. Phil. Soc. N. S. 7: 412. 1841, in part, as to plant of Rocky Mountains; Greene,

[1] In the original publication of this species Nuttall states: "HAB. Rocky Mountains (banks of the Platte) also banks of the Missouri." It is to be assumed, therefore, that two collections are involved. In the Gray Herbarium of Harvard University there are two specimens, one labelled in Nuttall's handwriting "*Senecio *Purshii, Cineraria integrifolia* Ph. non Willd., R. Mts.," the other "*S. purshianus,* Nutt! Rky. Mts. & Platte, Nutt!" These two specimens are clearly identical and are taken by the writer to be the historical type of *Senecio Purshianus* Nutt. In the Herbarium of the Philadelphia Academy of Natural Sciences there is also a specimen which Nuttall included in his species, since its label bears the following annotation in Nuttall's handwriting: "**Purshiana* N. (Nutt.)." The data originally recorded on the label is "*Senecio integrifolia?, Cineraria* Ph. etc. Missouri." As to this handwriting, I am not cer-

Pittonia **4** : 111. 1900; Rydb. Mem. N. Y. Bot. Gard. **1** : 445. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902; Rydb. Fl. Colo. 395. 1906; Daniels, Univ. Mo. Studies, Sci. Ser. **2** : 399 [251]. 1911.

S. canus Torr. & Gray, Fl. N. Am. **2** : 443. 1843, in part, not Hook.; Gray, Syn. Fl. N. Am. **1**^{2} : 390. 1884, and ed. 2, 1886, in part, not Hook.; Rydb. Contr. U. S. Nat. Herb. **3** : 510. 1896, in part, not Hook., i. e. as to No. 831.

S. Laramiensis Nelson, Bull. Torr. Bot. Club **26** : 483. 1899.

S. collinus Nelson, in Herb.

S. canus Purshianus Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 581. 1909; Fl. Intermountain States, 175. 1912.

A low cespitose herbaceous perennial, white-tomentose throughout, rarely glabrate; stems usually 1 to 2 dm., rarely 3, high, simple or branched; basal and lower stem-leaves mostly narrowly oblanceolate, occasionally oblong-obovate, including the petiole 2 to 12 cm. long, 3 to 15 mm. broad, rounded to obtuse at the apex, densely tomentose on both surfaces, occasionally somewhat glabrate; upper stem-leaves similar, lanceolate to linear, sessile, entire or somewhat dentate, often ampliated into a lobed or semiamplexicaul base; inflorescence a terminal few to several-headed close or open cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate, tomentulose to essentially glabrous; bracts of the involucre usually 13, occasionally fewer, linear-lanceolate, 5 to 7 mm. long; ray-flowers about 8, rays yellow; disk-flowers commonly 30 to 45; achenes glabrous.

Distribution: South Dakota and northwestern Nebraska, west to Montana and Colorado.

tain, but it may very well be that of Pursh. However, the plant is doubtless the specimen to which Nuttall referred, as "banks of the Missouri"; furthermore, in all probability it is the plant cited by Pursh (Flora Americae Septentrionalis **2** : 528. 1814, and ed. 2, 1816), under *Cineraria integrifolia β. minor*, as "on banks of the Missouri, *M. Lewis.*" This specimen differs from Nuttall's Rocky Mountain specimens above mentioned in being somewhat taller, in having broader leaves, larger heads, longer and more numerous involucral bracts; it is unquestionably *Senecio canus* Hook.

Specimens examined:

Rocky Mountains: without definite locality, *Nuttall* (Gray Herb.), TYPE; "Rky. Mts. & Platte," *Nuttall* (Gray Herb.).

South Dakota: Hot Springs, alt. 1065 m., 13 June, 1892, *Rydberg 831* (Gray Herb. and U. S. Nat. Herb.).

Nebraska: on sterile hills, White River Valley, May, 1855, *Hayden* (Mo. Bot. Gard. Herb.); Warbonnet Cañon, alt. 1525 m., June, 1890, *ex Herb. T. A. Williams* (Mo. Bot. Gard. Herb.).

Montana: high sterile hills on the Yellowstone River, coll. of 1853–1854, *Hayden* (Mo. Bot. Gard. Herb.); on Teton River in the Rocky Mountains, June, 1854, *Doty* (Mo. Bot. Gard. Herb.); Little Belt Mountains, alt. 2285 m., 12 Aug., 1883, *Scribner 121* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.); near Jefferson River, 15 June, 1883, *Scribner 121b* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.); Madison River, 13 June, 1883, *Scribner 121c* (Phil. Acad. Nat. Sci. Herb.); near Livingston, 5 June, 1883, *Scribner 121a* (Gray Herb.), and *121d* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.); Mt. Helena, Helena, 30 June, 1883, *Canby 205* (Phil. Acad. Nat. Sci. Herb.); rocks above Hodson's Coal Mine, 4 Aug., 1887, *F. H. Knowlton* (U. S. Nat. Herb. No. 201423); Livingston, 25 May, 1901, *Mrs. E. W. Scheuber 171* (U. S. Nat. Herb. and Mont. Agr. Coll. Herb.); Bozeman, 30 June, 1888, *F. H. Knowlton* (U. S. Nat. Herb. No. 202932); Belt Creek, June, 1883, *F. W. Anderson 545* (U. S. Nat. Herb. No. 515547); Custer, 22 May, 1890, *Blankinship 37* (U. S. Nat. Herb., Mont. Agr. Coll. Herb., and Mo. Bot. Gard. Herb.); Helena, July, 1891, *F. D. Kelsey* (Mont. Agr. Coll. Herb.); Great Falls, 16 June, 1891, *R. S. Williams 78* (U. S. Nat. Herb. and Mont. Agr. Coll. Herb.); near Red Lodge, 28 July, 1893, *Rose 87* (U. S. Nat. Herb.); Spanish Basin, Madison Range, alt. 1825 m., 10 and 18 July, 1896, *Flodman 904, 905* (U. S. Nat. Herb.); Little Belt Mountains, near the Pass, alt. 2130 m., 10 Aug., 1896, *Flodman 903* (U. S. Nat. Herb.); vicinity of Missoula, 31 May, 1897, *M. J. Elrod 86* (Mont. Agr. Coll. Herb.); Bridger Mountains, alt. 2130 m., 12 June, 1897, *Rydberg & Bessey 5258* (Gray Herb., Berlin Herb., Mont. Agr. Coll. Herb., and U. S. Nat. Herb.);

Spanish Basin, Gallatin Co., alt. 1980 m., 15 June, 1897, *Rydberg & Bessey 5259* (Gray Herb., Mont. Agr. Coll. Herb., Berlin Herb., and U. S. Nat. Herb.); Gallatin and Park Counties, without date, *Burle Jones* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); dry uplands, Bozeman, 29 June, 1897, *Blankinship* (Gray Herb.); Baltic, 30 May, 1900, *E. V. Wilcox 278* (U. S. Nat. Herb.); Sedan, Gallatin Co., 11 June, 1901, *B. J. Jones* (Gray Herb.); university campus and hillsides, Missoula, alt. 1000 m., 11 June, 1901, *MacDougal 124* (Gray Herb. and U. S. Nat. Herb.); hills, Midvale, 16 June, 1903, *Umbach 70* (U. S. Nat. Herb.); Bozeman, 16 June, and dry ridges, Mt. Bridger, alt. 1825 m., 17 July, 1905, *Blankinship 290* (Phil. Acad. Nat. Sci. Herb. and U. S. Nat. Herb.); Mystic Lake, alt. 2040 m., 11 July, 1905, *Blankinship 290* (Mo. Bot. Gard. Herb.); near Bozeman, without date, *V. K. Chestnut & W. W. Jones 231* (U. S. Nat. Herb.).

Yellowstone National Park: East Fork, July, 1885, *Tweedy* (U. S. Nat. Herb.); dry hills near Mammoth Hot Springs, alt. 1825 m., June, 1893, *Burglehaus* (U. S. Nat. Herb. No. 49295); dry gravelly slopes, Glen Creek, 30 June, 1899, *A. & E. Nelson 5577* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); without definite locality, 13, 17, and 20 May, and 12, 15, and 18 June, 1902, *Mearns 690, 760, 825, 1061, 1153, 1225* (U. S. Nat. Herb.); Electric Peak, 26 July, 1902, "*E. C. S.*" *181* (U. S. Nat. Herb.).

Wyoming: rich wooded bottoms in Jackson's Hole on Snake River, alt. 1825 m., 15 June, 1860, *Hayden* (Mo. Bot. Gard. Herb.); on Madison River, alt. 1370–2130 m., 28 June, 1860, *Hayden* (Mo. Bot. Gard. Herb.); Northwestern Wyoming Exp., coll. of 1873, *Parry 169* (Gray Herb.); Yellowstone River, coll. of 1878, *Havard* (Gray Herb.); without locality, *Tweedy* (U. S. Nat. Herb. No. 49294); Horse Creek, 6 June, 1893, *A. Nelson 36* (U. S. Nat. Herb.); Saratoga, without date, *A. Nelson 115* (U. S. Nat. Herb.); northwestern Wyoming, coll. of 1893, *Rose 148* (U. S. Nat. Herb.); Red Hills, north of Laramie, 4 June, 1894, *A. Nelson 178* (Phil. Acad. Nat. Sci. Herb.); dry soil, Laramie Hills, 15 June, 1894, *A. Nelson 224* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), *type*

of *S. Laramiensis;* Green River, 25 June, 1895, *Shear 4373* (U. S. Nat. Herb.); Pole Creek, 30 June, 1895, *A. Nelson 1379* (Mo. Bot. Gard. Herb.); Laramie Hills, 25 June, 1898, *A. Nelson 4360* (Mo. Bot. Gard. Herb.), *type* of *S. collinus;* Hoodoo Peak, alt. 3350 m., 10 Aug., 1897, *P. Koch 20* (Mont. Agr. Coll. Herb.); naked, red, triassic ridges, Sand Creek, Albany Co., 31 May, 1900, *A. Nelson 6957* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Hunt Mountain, Big Horn Mountains, alt. 3050 m., 21 July, 1900, *J. G. Jack* (Gray Herb.); dry subalpine slopes, Medicine Bow Mountains, Albany Co., 2 Aug., 1900, *A. Nelson 7935* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); river bottoms, Encampment, Carbon Co., alt. 2740 m., 15 June, 1901, *Tweedy 4123* (U. S. Nat. Herb.); crevices of rocks, Leucite Hills, 17 June, 1901, *Merrill & Wilcox 505* (U. S. Nat. Herb.); dry grounds, Point of Rocks, 17 June, 1901, *Merrill & Wilcox 669* (U. S. Nat. Herb.); dry hillsides, Dyer's Ranch, Carbon Co., 21 June, 1901, *Goodding 79* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); dry hillsides, Red Buttes, Albany Co., June, 1903, *A. Nelson 8937* (U. S. Nat. Herb.).

Colorado: dry summits at limit of trees, near Golden City, coll. of 1871, *E. L. Greene 534* (Gray Herb.); Floral Mountain, near Georgetown, alt. 3960 m., 16 Aug., 1884, *C. S. Sheldon 274* (U. S. Nat. Herb.); Silverton, July, 1889, *Eastwood* (U. S. Nat. Herb.); Mt. Princeton, Chaffee Co., alt. 3655 m., 23 July, 1892, *C. S. Sheldon 162, 482* (U. S. Nat. Herb.); mountains northeast of Boreas, alt. 3350–3960 m., 2 Aug., 1895, *State Agr. Coll. Colo. 3028* (U. S. Nat. Herb.); alpine rocky ridges, Rabbit Ears, Larimer Co., 14 June, 1903, *Goodding 1539* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Utah: Uintas, alt. 3810 m., Aug., 1869, *Watson 672* (Gray Herb. and U. S. Nat. Herb.); Brigham Peak, alt. 3565 m., 29 Aug., 1894, *M. E. Jones 5941* (Mo. Bot. Gard. Herb.); Mt. Barrette, 26 July, 1905, *Rydberg & Carlton 7222* (U. S. Nat. Herb.).

121. S. Howellii Greene, Bull. Torr. Bot. Club **8**: 98. 1881; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot.

Jahrb. **32** : 20. 1902; Piper, Contr. U. S. Nat. Herb. **11** : 599. 1906; Piper & Beattie, Fl. S. E. Wash. & Adjacent Idaho, 274. 1914.

S. canus Torr. Bot. Wilkes' U. S. Expl. Exp. 367. 1874, in part, not Hook.; Gray, Syn. Fl. N. Am. 1^2: 390. 1884, and ed. 2, 1886, in part, not Hook.; Holzinger, Contr. U. S. Nat. Herb. **3** : 235. 1895, not Hook.

S. Purshianus Howell, Fl. N. W. Am. **1** : 378. 1900, not Nutt.

An herbaceous cespitose perennial, at first white-tomentose, later more or less glabrate; stems 1 to 3 dm. high, erect, simple or branched, rather freely stoloniferous at the base; basal and lower stem-leaves elliptic-lanceolate to narrowly oblanceolate, including the petiole 2 to 12 cm. long, .5 to 1.5 cm. broad, obtuse or acute at the apex, entire to subpinnately and irregularly lobed, narrowed below into a slender petiole equalling or exceeding the blade, at first white-tomentose on both surfaces, later more or less glabrate especially on the upper surface, margins often revolute; upper stem-leaves usually much reduced, lanceolate to lance-linear, sessile, entire to dentate-lobed, not infrequently subauriculate at the base; inflorescence a terminal few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre usually about 13, linear-lanceolate, 5 to 7 mm. long, glabrous or nearly so; ray-flowers about 8, rays yellow; disk-flowers 30 to 40; achenes glabrous.

Distribution: Idaho and Washington, south to Utah and northern California.

Specimens examined:

Idaho: valley of Spokane River, Kootenai Co., 18 July, 1892, *Sandberg, MacDougal & Heller 668* (U. S. Nat. Herb.); Big Butte Station, 21 June, 1893, *E. Palmer 206* (U. S. Nat. Herb.); about Lake Waha, Nez Perces Co., alt. 610–1065 m., 29 June, 1896, *A. A. & E. G. Heller 3340* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.), form with both radiate and discoid heads; dry hillsides, Three Creek, Owyhee Co., 1 July, 1912, *Nelson & Macbride 1863* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); dry soil, Fernan Flats, Coeur d'Alene, July, 1912, *H. J. Rust 112* (U. S. Nat. Herb.); old lava plain, Martin,

Blaine Co., alt. 1830 m., 5 July, 1916, *Macbride & Payson 3038* (Mo. Bot. Gard. Herb.); moist protected slopes among rocks, western slope of Lemhi Mountains, near Patterson, Lemhi Co., alt. 1950 m., *Macbride & Payson 3196* (Mo. Bot. Gard. Herb.).

Washington: "Columbia River opposite the mouth of the Deschutes," Klickitat Co., June, 1881, *Howell* (Gray Herb., Greene Herb., Univ. of Notre Dame, and U. S. Nat. Herb.); stony hillsides, upper Columbia River, June, 1881, *T. J. Howell* (Greene Herb., Univ. of Notre Dame), TYPE—originally recorded by Greene as "on the upper Columbia River in Oregon"; Spokane Co., 14 June, 1884, *Suksdorf 375* (Gray Herb.); Hangman Creek, Spokane Co., 10 June, 1889, *Suksdorf 934* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); near Rock Island, Kittitas Co., alt. 760 m., 14 July, 1893, *Sandberg & Leiberg 457* (U. S. Nat. Herb.); in loose gravel, Spokane, 2 July, 1896, *C. V. Piper 2267* (Gray Herb.); between Grand Ronde Cañon and Fisher's Gulch, alt. 1250 m., 1 June, 1897, *Sheldon 8227* (Field Mus. Herb.); hill near Wenatchee, 9 June, 1901, *Whited 1361* (U. S. Nat. Herb.); Clark Springs, Spokane, 7 July, 1902, *F. O. Kreager 98* (Gray Herb. and U. S. Nat. Herb.); hillsides, Wenatchee Mountains, Kittitas Co., alt. 1615 m., 29 June, 1903, *J. S. Cotton 1249* (Gray Herb.); Cheyney, Spokane Co., *Mrs. Susan Tucker 90* (Gray Herb.); Wenatchee, 19 May, 1905, *Whited 2622* in part (U. S. Nat. Herb. No. 620360); south of Gulch No. 2, Wenatchee, 11 June, 1899, *Whited 1142* (U. S. Nat. Herb.).

Oregon: Cascade Mountains, coll. of 1860, *Dr. Lyall* (Gray Herb.); without definite locality, Wilkes' U. S. Expl. Exp., 1838–1842, *Wilkes* (U. S. Nat. Herb. No. 49288 in part); without definite locality, *Geyer 489* (Gray Herb.); Union Co., coll. of 1878, *Cusick 636* (Gray Herb.); Union Co., coll. of 1883, *Cusick 1095* (Gray Herb.); Cold Camp and Harvey Valley, 11 May, 1885, *Howell 455, 456* (Gray Herb.); Stein's Mountains, 28 May, 1885, *Howell* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); near camp on Pine Creek, Gilliam Co., alt. 1090 m., 7 June, 1894, *Leiberg 169* (U. S. Nat. Herb., Mo. Bot. Gard. Herb., and Univ. Ariz. Herb.), form with most of the leaves lobed; Otis Creek, Malheur Co., alt. 1100 m., 19 June,

1896, *Leiberg 2328* (U. S. Nat. Herb.); Strawberry Butte, Blue Mountains, above timber line, alt. 2665–2770 m., 13 July, 1896, *Coville 562* (U. S. Nat. Herb.); hills, Malheur Co., June, 1897, *Cusick 1626* (Mo. Bot. Gard. Herb.); without definite locality, coll. of 1897, *Sheldon 8227, 8403* (U. S. Nat. Herb.); Stein's Mountains, 30 June, 1898, *Cusick 2188* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); in pumice field at the Palisades, Crater Lake National Park, 4 Sept., 1902, *Coville 1476* (U. S. Nat. Herb.); on rocky ledges, Pilot Butte, Crook Co., 19 June, 1905, *E. Nelson 856* (Mo. Bot. Gard. Herb.); dry sagebrush land, vicinity of Laidlaw, Crook Co., 10 July, 1906, *Whited 3058* (U. S. Nat. Herb.); Forked Horn Butte, 2 June, 1907, *Whited* (U. S. Nat. Herb. No. 620384); abundant on outskirts of open yellow pine forests, Billy Meadows, Wallowa National Forest, 7 Aug., 1908, *James T. Jardine 345* (U. S. Nat. Herb.); common on the desert, near Laidlaw, 15 June, 1912, *Whited A54* (U. S. Nat. Herb.).

Nevada: Summit Lake Region, July, 1901, *Griffiths & Morris 319* (U. S. Nat. Herb.); Clover Mountain Range, near Deeth, Elko Co., alt. 2070 m., 22 July, 1908, *Heller 9101* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); moist ravine, Bunker Hill, Toiyabe Forest, alt. 2250–3400 m., *Hitchcock 854* (U. S. Nat. Herb.); Bunker Hill, Toiyabe Range, Lander Co., alt. 3200 m., 29 July, 1913, *Kennedy 4086* (Mo. Bot. Gard. Herb.); dry hill, Pine Mountain, vicinity of Gold Creek, 7 Aug., 1913, *Hitchcock 1102* (U. S. Nat. Herb.); Ruby Mountains, near Blaine Post-office, alt. 2710 m., 22 Aug., 1913, *Heller 11097* (Mo. Bot. Gard. Herb.).

California: Modoc Co., July, 1885, *Mrs. R. M. Austin* (U. S. Nat. Herb. No. 310576); White Mountains, Mono Co., alt. 3655 m., 19 Aug., 1888, *Shockley 598* (Gray Herb.); on rocky ridge at Castle Peak, (?) Mono Co., alt. 2740 m., 7 Aug., 1900, *Leiberg 5292* (U. S. Nat. Herb. No. 610540).

Var. **lithophilus** Greenm. Bot. Gaz. **48**: 148. 1909.

S. aureus var. *borealis* Torr. Bot. Wilkes' U. S. Expl. Exp. 307. 1874, not Torr. & Gray.

Stems 1 to 3 dm. high, erect or ascending; basal and lower stem-leaves subovate to oblanceolate, including the petiole 1.5

to 15 cm. long, .5 to 3 cm. broad, rounded to obtuse at the apex, entire to irregularly dentate-lobed, occasionally somewhat glabrate; upper stem-leaves often relatively large and conspicuous.

Distribution: western Montana to Washington and Oregon.

Specimens examined:

Montana: ridge above Missoula, 2 Aug., 1880, *Watson 234* (Gray Herb.); Missoula Valley, July, 1892, *Aiton* (Mo. Bot. Gard. Herb.); Bozeman Cañon, 25 July, 1895, *C. L. Shear 3522* (U. S. Nat. Herb.); dry ground, Hamilton, alt. 1065 m., 14 June, 1906, *Blankinship 779* (U. S. Nat. Herb.); dry hillsides, Lolo Valley, Lolo, Aug., 1912, *J. E. Kirkwood 80* (Mo. Bot. Gard. Herb.).

Idaho: in loose gravel and on granite ledges, subalpine stations around Lake Pend d'Oreille, June, 1891, *Leiberg 556* (Mo. Bot. Gard. Herb.); mountain tops of Salmon River Mountains, alt. 3750 m., 17 Aug., 1895, *Henderson 3845* (U. S. Nat. Herb.), form; in small clumps on granite, Mackay, Custer Co., 1 Aug., 1911, *Nelson & Macbride 1540* (Mo. Bot. Gard. Herb.); sagebrush draws, Lost River Mountains, near Clyde, Blaine Co., 10 July, 1916, *Macbride & Payson 3847* (Mo. Bot. Gard. Herb.); dry rocky slopes, Squaw Creek, near Clayton, Custer Co., 23 July, 1916, *Macbride & Payson 3371* (Mo. Bot. Gard. Herb.).

Washington: Wenatchee, 19 May, 1905, *Whited 2622* in part (U. S. Nat. Herb. No. 620359).

Oregon: east side of Cascade Mountains, Wilkes' U. S. Expl. Exp., 1838–1842, *Wilkes* (U. S. Nat. Herb. No. 40121); Stein's Mountains, opposite Devine Ranch, alt. 2200 m., 4 July, 1896, *Leiberg 2481* (U. S. Nat. Herb.); hills, Malheur Co., June, 1897, *Cusick 1626* (U. S. Nat. Herb.); Crow Creek, Wallowa Co., alt. 1250 m., *Sheldon 8403* (Mo. Bot. Gard. Herb.); dry rocky granitic soil, on the Imnaha River, Wallowa Mountains, alt. 2000 m., Aug., 1906, *Cusick 3129* (Field Mus. Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), TYPE; limestone rocks, source of the Imnaha, alt. 2740 m., 14 Aug., 1910, *Cusick 3382* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Var. **eradiatus** (Wats.) Greenm. comb. nov.

S. canus var. *eradiatus* Wats. Bot. King's Exp. 190. 1871.

Stems about 1 dm. high; lower leaves subovate to oblanceolate, including the petiole 3 to 8 cm. long, .5 to 2 cm. broad, entire or somewhat dentate; heads discoid.

Specimens examined:

Nevada: East Humboldt Mountains, alt. 3050 m., U. S. Geol. Expl. of the 40th Parallel, Aug., 1868, *Watson 673* (Gray Herb. and U. S. Nat. Herb.), TYPE.

122. S. oreopolus Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902, name only; Ann. Mo. Bot. Gard. **1** : 268, *pl. 11.* 1914.

S. canus Gray, Bot. Calif. **1** : 412. 1876, in part, not Hook.; Coville, Contr. U. S. Nat. Herb. **4** : 139. 1893, not Hook.; Greene, Fl. Franciscana, 469. 1897, not Hook.

S. kernensis Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902.

A low herbaceous perennial, white-tomentose throughout; stems erect or nearly so, simple or branched, .8 to 3 dm. high, often producing elongated slender stolons at the base; basal and lower stem-leaves petiolate, ovate to ovate-elliptic, including the petiole 2 to 10 cm. long, .5 to 2 cm. broad, rounded to obtuse or sometimes acute at the apex, entire or sparingly dentate, usually permanently white-tomentose on both surfaces, occasionally more or less glabrate, thick and firm in texture; uppermost stem-leaves sessile, lance-linear, entire to irregularly dentate; inflorescence a terminal corymbose cyme; heads few to many, about 1 cm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre commonly 13 (9–13), narrowly lanceolate, 5–7 mm. long, acute, glabrous or slightly tomentulose; ray-flowers 5 to 13, rays yellow; disk-flowers 20 to 30; achenes glabrous.

Distribution: high mountains of California and western Nevada.

Specimens examined:

California: near summit of Silver Mountain, alt. 3350 m., Geol. Surv. Calif., 5 Aug., 1863, *Brewer 2050* (Gray Herb. and U. S. Nat. Herb.); Sonora Pass, alt. 2435–2740 m., Geol. Surv.

Calif., July, 1863, *Brewer 2686* (Gray Herb. and U. S. Nat. Herb.); hill above Camp 131, Ebbett's Pass, alt. 2590–2740 m., Geol. Surv. Calif., 1 Aug., 1863, *Brewer 2005* (Gray Herb. and U. S. Nat. Herb.); Mono Pass, Geol. Surv. Calif., 1866, *Bolander 6140* (Gray Herb. and U. S. Nat. Herb.); South Fork of Kern River, alt. 3718 m., Wheeler's Expl. & Surv. west of the 100th Meridian, Sept., 1875, *Rothrock 334* (Gray Herb., U. S. Nat. Herb., and Field Mus. Herb.), *type* of *S. kernensis;* Sierra Nevada, coll. of 1875, *John Muir 4452* (Mo. Bot. Gard. Herb.); Mt. Shasta, above timber line, Aug., 1877, "*A. S. P. Jr.*" (Field Mus. Herb. No. 277271); Mt. Stanford, 17 July, 1887, *C. F. Sonne 373* (Phil. Acad. Nat. Sci. Herb.); near Whitney Meadows, Sierra Nevada, 20 Aug., 1891, Death Valley Exp., *Coville & Funston 1647* (U. S. Nat. Herb.); gravelly slopes, Little Kern River, alt. 3050–3350 m., April–Sept., 1897, *Purpus 5240* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); north side near Sheep Rock, Mt. Shasta, Siskiyou Co., alt. 853 m., June, 1903, *Hall & Babcock 4095* (Gray Herb.); Castle Peak, near the highest point, alt. 2740 m., 5 Aug., 1903, *Heller 7102* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., C. C. Deam Herb., and Mo. Bot. Gard. Herb.); Natural Bridge, Volcano Creek, basin of the Upper Kern River, Tulare Co., alt. 2285 m., July, 1904, *Hall & Babcock 5433* (Gray Herb.); Rock Creek Cañon, basin of the Upper Kern River, Tulare Co., alt. 3050 m., July, 1904, *Hall & Babcock 5526* (Gray Herb. and Univ. Ariz. Herb.), TYPE.

Nevada: Mt. Rose, Washoe Co., 25 July, 1907, *C. L. Brown* (Phil. Acad. Nat. Sci. Herb. No. 537022); Mt. Rose, Washoe Co., alt. 3200 m., 28 July, 1909, and 26 Aug., 1911, *Heller 9882* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Forma **aphanactis** Greenm. Ann. Mo. Bot. Gard. **1**: 269. 1914.

Stems about 1 dm. high; leaves including the petiole 1.5 to 2.5 cm. long, 5 to 7 mm. broad; heads discoid.

Specimens examined:

California: mountain peak, near Sonora Pass, alt. 3200 m., Geol. Surv. Calif., 1863, *Brewer 1905* (Gray Herb. and U. S. Nat. Herb.), TYPE.

123. S. Hallii Britton, Trans. N. Y. Acad. Sci. **9** : 11. 1889; Rydb. Mem. N. Y. Bot. Gard. **1** : 445. 1900. Pl. 4, fig. 2.

A low cespitose herbaceous perennial, densely and conspicuously white-tomentose throughout; stems erect, 1 to 1.8 dm. high, simple or branched; basal and lower stem-leaves spatulate to oblanceolate, 1.5 to 5 cm. long, 4 to 10 mm. broad, densely and permanently white-tomentose on both surfaces, rounded to obtuse at the apex, entire, often revolute-margined, narrowed into a petiole about equalling the blade; upper stem-leaves few, sessile, lanceolate, and often somewhat ampliated into an entire or toothed semiamplexicaul base; inflorescence a terminal few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre about 13, linear-lanceolate, 5 to 6 mm. long, at first densely white-tomentose, later more or less glabrate; ray-flowers 8, rays pale yellow; disk-flowers about 30; achenes glabrous.

Distribution: known only from geyser formations of Yellowstone National Park.

Specimens examined:

Yellowstone National Park: on geyserite, June, 1888, *Rev. Dr. Charles H. Hall* (N. Y. Bot. Gard. Herb. and Greene Herb., Univ. of Notre Dame), TYPE; directly on geyserite, Shoshone Geyser Basin, alt. 2375 m., 23–26 Aug., *"C. R."* (Gray Herb.); National Park, alt. 2438 m., 3 Aug., 1885, *Letterman 259* (Mo. Bot. Gard. Herb.); Upper Geyser Basin, alt. about 2135 m., 8 Aug., 1897, *Rydberg & Bessey 5257* (Gray Herb., Greene Herb., Univ. of Notre Dame, Mont. Agr. Coll. Herb., and U. S. Nat. Herb.); Mammoth Hot Springs, 5 July, 1899, *Blankinship* (Gray Herb.); Upper Geyser Basin, 12 July, 1899, *Blankinship* (Gray Herb.); Lower Geyser Basin, 13 July, 1899, *Blankinship* (Gray Herb.); without definite locality, 16 Sept., 1902, *Mearns 4059* (U. S. Nat. Herb.); Upper Basin, 17 July, 1912, *Churchill* (J. R. Churchill Herb.).

124. S. candidissimus Greene, Pittonia **4** : 110. 1900.

An herbaceous perennial, densely and permanently white-tomentose throughout; stems ascending or suberect, 1.5 to 2.5

dm. high, from a more or less elongated subligneous rootstock; leaves chiefly basal, oblong-obovate to narrowly oblong-oblanceolate, 3 to 7 cm. long, .5 to 1.5 cm. broad, rounded to obtuse at the apex, entire or subdentate towards the tip, gradually narrowed below into a slightly winged petiole, persistently white-tomentose on both surfaces, margins often revolute; upper stem-leaves few, much reduced, bracteiform; inflorescence a terminal few-headed corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate, tomentulose; bracts of the involucre 13 to 21, linear-lanceolate, about 6 mm. long, acute; ray-flowers commonly 8, rays yellow; disk-flowers about 50; achenes glabrous.

Distribution: mountains of northern Mexico.

Specimens examined:

Chihuahua: near Colonia Garcia in the Sierra Madre, alt. 2285 m., 24 May, 1899, *Townsend & Barber 1* (Greene Herb., Univ. of Notre Dame, Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), TYPE; Sierra Madre, 21 June–29 July, 1899, *E. W. Nelson 6005* (U. S. Nat. Herb.).

125. S. bellidifolius HBK. Nov. Gen. & Sp. **4**: 175. 1820; Schlecht. & Cham. Linnaea **5**: 161. 1830; DC. Prodr. **6**: 429. 1837; Hemsl. Biol. Cent.-Am. Bot. **2**: 236. 1881.

S. pauciflorus HBK. Nov. Gen. & Sp. **4**: 176, *pl. 365*. 1820, not Pursh.

S. cheiranthifolius HBK. Nov. Gen. & Sp. **4**: 176. 1820; DC. Prodr. **6**: 429. 1837; Hemsl. Biol. Cent.-Am. Bot. **2**: 237. 1881.

S. Vulneraria DC. Prodr. **6**: 428. 1837; Hemsl. Biol. Cent.-Am. Bot. **2**: 248. 1881; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902.

S. tricephalus Klatt in Herb.

Cineraria vulneraria Alam. ex DC. Prodr. **6**: 428. 1837.

A low cespitose herbaceous perennial, at first white-tomentose throughout, more or less glabrate; stems erect or nearly so, 1 to 2.5 dm. high; leaves chiefly basal, subobovate to narrowly oblong-oblanceolate, 2 to 8.5 cm. long, 5 to 12 mm. broad, rounded to submucronate-acute at the apex, entire to somewhat dentate, gradually narrowed below into a petiole equal-

ling or exceeding the blade, at first white-tomentose on both surfaces, more or less glabrate especially on the upper surface, margins often revolute; upper stem-leaves few, remote, linear or linear-lanceolate, bracteiform; inflorescence a terminal few-headed (1–5) cyme; heads 10 to 14 mm. high, sessile or pedunculate, radiate; involucre campanulate, sparingly calyculate, tomentulose; bracts of the involucre 13 to 21, linear-lanceolate, 7 to 8 mm. long; ray-flowers about 10, rays yellow; disk-flowers 45 to 60; achenes glabrous.

Distribution: Mexico.

Specimens examined:

Chihuahua: vicinity of Madera, alt. about 2250 m., 27 May–3 June, 1908, *Dr. Ed. Palmer 277* (U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.).

State of Mexico: Nevada de Toluca, alt. 3960 m., 2 Sept., 1892, *Pringle 5332* (Gray Herb. and Mo. Bot. Gard. Herb.); meadows, Mt. Ixtaccihuatl, alt. 3350–3655 m., March–July, 1903, *Purpus 267* (Mo. Bot. Gard. Herb.).

Federal District: grassy slopes, Serrania de Ajusco, alt. 2985 m., 16 April, 1898, *Pringle 6797* (Gray Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

Hidalgo: open spaces, Sierra de Pachuca, alt. 3050 m., 23 Aug., 1902, *Pringle 9960* (Gray Herb. and Mo. Bot. Gard. Herb.).

Southern Mexico: near Huajalote Rancho, March, 1837, *Ehrenberg 847* (Berlin Herb. and Gray Herb.); Jorullo, *Humboldt & Bonpland* (Berlin Herb., fragment and tracing in Gray Herb.), TYPE; Mt. Orizaba, *Schiede 359* (Berlin Herb., tracing in Gray Herb.); peak of Orizaba, alt. 3500 m., June–Oct., 1840, *Galeotti 2184* (Gray Herb.); Province of Vera Cruz, alt. 3050–3655 m., April, 1856, *Sartorius* (Gray Herb.); peak of Orizaba, *Liebmann 141* (Copenhagen Herb., fragment and tracing in Gray Herb.); near Moran and Regla, *Humboldt & Bonpland* (Paris Herb., tracing in Gray Herb.), *type* of *S. cheiranthifolius;* Mt. Orizaba, alt. 4265 m., 7 Aug., 1891, *Seaton 239* (Gray Herb.); slope of Mt. Orizaba, alt. 4420 m., 25 Feb., 1892, *J. G. Smith* (Mo. Bot. Gard. Herb.).

126. S. loratifolius Greenm. Proc. Am. Acad. **43**: 21. 1907. Pl. 5.

An herbaceous perennial; stems erect, about 3 dm. high, white-lanate-tomentose; leaves alternate, narrowly elongate-lanceolate or sublorate, .5 to 1.7 dm. long, 4 to 12 mm. broad, acute or obtuse, entire, membranous, in the early stages lightly floccose-tomentulose on the upper surface and more or less glabrate, densely and permanently white-tomentose beneath; the lower leaves gradually narrowed into a petiole-like base, the upper, sessile and amplexicaul; inflorescence a terminal few-headed subcorymbose cyme; heads radiate, 8 to 10 mm. high; involucre campanulate, calyculate, tomentose; bracts of the involucre usually 13, linear-lanceolate, 6 to 7 mm. long; ray-flowers 8 to 12, rays yellow; disk-flowers about 35; achenes hispidulous.

Distribution: northern Mexico.

Specimen examined:

Coahuila: mountains near Saltillo, alt. 2150 m., 5 Oct., 1905, *C. G. Pringle 13676* (Gray Herb.), TYPE.

127. S. cynthioides Greene, Leafl. Bot. Obs. & Crit. **1**: 212. 1906; Wooton & Standley, Contr. U. S. Nat. Herb. **19**: 748. 1915.

S. fastigiatus Gray, Pl. Wright., pt. 2, 99. 1853, not Nutt.

S. Wrightii Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902, name only; Ann. Mo. Bot. Gard. **1**: 269. 1914.

S. Fendleri var. *subintegra* Greene in Herb.

An herbaceous perennial, subtomentose throughout, more or less glabrate especially on the upper leaf-surface; stems erect, 1 to 4 dm. high, usually rather leafy; leaves narrowly oblong-oblanceolate to lanceolate-linear, entire or sparingly dentate towards the tip, rounded to obtuse at the apex, in the early stages somewhat tomentulose on the upper surface but soon glabrate, more or less persistently white-tomentulose beneath, the lowermost leaves gradually narrowed into a petiole; upper stem-leaves sessile, often ampliated and irregularly dentate at the semiamplexicaul base; inflorescence a terminal sub-

corymbose many-headed cyme; heads 8 to 10 mm. high, minutely calyculate, radiate; involucre campanulate; bracts of the involucre usually 13, narrowly lanceolate, 5 to 7 mm. long, acute, tomentose to nearly glabrous; ray-flowers 6 to 8, rays narrowly oblong, about 8 mm. long, 4–5-nerved, yellow; disk-flowers about 30; achenes glabrous.

Distribution: mountains of New Mexico and Arizona.

Specimens examined:

New Mexico: Mogollon Mountains, alt. 2435 m., 23 Aug., 1903, *Metcalfe 574* (Greene Herb., Univ. of Notre Dame, U. S. Nat. Herb., Univ. Ariz. Herb., and Mo. Bot. Gard. Herb.), TYPE; ravines between the Copper Mines and the Mimbres, Oct., 1851, *Wright 1289* (Gray Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.), *type* of *S. Wrightii;* valley of the Rio Grande, *Mex. Bound. Survey 656* (U. S. Nat. Herb. Nos. 49352, 49353); Santa Rita del Cobre, 22 Sept., 1880, *E. L. Greene* (Mo. Bot. Gard. Herb.); Lookout Mine, Sierra Co., 22 July, 1904, *Metcalfe 1179* (Mo. Bot. Gard. Herb.); open slope, Navajo Indian Reservation, in the Tunitcha Mountains, 8 Aug., 1911, *Standley 7678* (U. S. Nat. Herb.); Tierra Blanca Cañon, alt. 2070 m., 16 Aug., 1915, *W. R. Chapline* (U. S. Nat. Herb.).

Arizona: open steep slopes, head of Little Colorado River, 10 July, 1912, *Goodding 1146* (Univ. Ariz. Herb.).

128. S. fastigiatus Nutt. Trans. Am. Phil. Soc. N. S. **7**: 410. 1841; Torr. & Gray, Fl. N. Am. **2**: 439. 1843; Gray, Syn. Fl. N. Am. **1**^{2}: 390. 1884, and ed. 2, 1886, excl. var. *Layneae;* Heller, Cat. N. Am. Pl. 146. 1898, and ed. 2, 229. 1900; Howell, Fl. N. W. Am. 378. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**: 20. 1902; Piper, Contr. U. S. Nat. Herb. **11**: 599. 1906; Piper & Beattie, Fl. Northwest Coast, 389. 1915.

S. spatuliformis Heller, Bull. Torr. Bot. Club **26**: 552. 1899.

S. ligulifolius Greene, Leafl. Bot. Obs. & Crit. **2**: 14. 1909.

S. leucocrinus Greene, Leafl. Bot. Obs. & Crit. **2**: 14. 1909.

An herbaceous perennial, white-tomentose or floccose-tomentulose to nearly glabrous; stems one to several from an ascending rootstock, erect, 2 to 6 dm. high, simple or branched;

leaves narrowly oblong-oblanceolate, including the petiole 3.5 to 22 cm. long, .5 to 2 cm. broad, rounded to acute at the apex, entire or sinuately denticulate, gradually narrowed below into a slender petiole, thickish in texture, margins usually revolute; upper stem-leaves similar, gradually reduced towards the top of the stem to sessile, linear and entire or denticulate bracts; inflorescence a terminal few to several-headed corymbose cyme; heads about 1 cm. high, radiate; involucre campanulate, sparingly calyculate, tomentulose or glabrous; bracts of the involucre about 13, linear-lanceolate, 6 to 8 mm. long; ray-flowers commonly 8, rays yellow; disk-flowers 30 to 45; achenes glabrous.

Distribution: Vancouver Island to Oregon.

Specimens examined:

British Columbia: in tufts in sand, Qualicum, Vancouver Island, 29 July, 1887, *Macoun* (Gray Herb. and Geol. Surv. Canada Herb.); northern point of Texada Island, Gulf of Georgia, 26 June, 1885, *Dawson 14801* (Geol. Surv. Canada Herb.); in tufts on gravel, Goldstream, Vancouver Island, 27 June, 1887, *Macoun* (Geol. Surv. Canada Herb. No. 16584); Mt. Benson, Vancouver Island, 10 July, 1893, *Macoun 555* (Mo. Bot. Gard. Herb.); dry slopes, Bald Mountain, Vancouver Island, alt. 450 m., 17 June, 1907, *Rosendahl 1853* (U. S. Nat. Herb.); Shawningan Lake, Vancouver Island, 18 June, 1908, *Macoun* (Geol. Surv. Canada Herb. No. 78955); vicinity of Nanaimo, Vancouver Island, 4 July, 1908, *Macoun* (Geol. Surv. Canada Herb. Nos. 78952, 78953); Langford Lake, vicinity of Victoria, 24 July, 1908, *Macoun* (Geol. Surv. Canada Herb. No. 78954); Mathalchea Lake, 11 July, 1911, *Spreadborough* (Geol. Surv. Canada Herb. No. 91258); Langford Lake, near Victoria, 24 May, 1915, *Newcombe* (Mo. Bot. Gard. Herb.).

Washington: Mill Plain, June, 1877, *Howell* (Gray Herb.); moist sandy plains, coll. of 1883, *Henderson 24* (Gray Herb.); dryish prairies, Pierce Co., 17 July, 1883, collector not indicated (Piper Herb.); Yelm Prairie, 5 Aug., 1889, *E. C. Smith* (Mo. Bot. Gard. Herb.); Yelm Prairie, July, 1890, *E. C. Smith 538* (U. S. Nat. Herb.); Union City, 4 July, 1890, *Piper* (Mo.

Bot. Gard. Herb.); Mason Co., 20 July, 1890, *Piper 538* (U. S. Nat. Herb.); near Elma, Chehalis Co., alt. 60 m., 19 July, 1898, *A. A. & E. G. Heller 4061* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.), *type* of *S. spatuliformis* Heller; Mt. Constitution, 5 July, 1907, *Cowles 446* (Mo. Bot. Gard. Herb.); Orcas Island, July, 1909, *C. J. Brues* (Pub. Mus. Milwaukee Herb.); Seattle, July, 1915, *G. W. Freiberg* (Mo. Bot. Gard. Herb.); Seattle, July, 1915, *S. M. Zeller* (Mo. Bot. Gard. Herb.); Mt. Constitution, alt. about 610 m., 30 July, 1917, *S. M. & E. B. Zeller 1067* (Mo. Bot. Gard. Herb.).

Oregon: "plains of the Oregon, near Wahlamet," and "R. Mts." [probably Oregon] *Nuttall* (Gray Herb.), TYPE; Clear Water, *Rev. Mr. Spalding* (Gray Herb.); without locality, *E. Hall 305* (Gray Herb. and Mo. Bot. Gard. Herb.); prairies, western Oregon, June, 1880, *T. J. Howell* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); Portland, coll. of 1881, *Henderson 11* (Gray Herb.); Waldo, June, 1884, *Howell 161* (Gray Herb.); Blue Mountains, June, 1886, *Henderson* (Gray Herb.); Waldo, 14 June, 1904, *Piper 6102* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.), *type* of *S. ligulifolius* Greene; eight miles south of Waldo, 14 June, 1904, *Piper 6228* (U. S. Nat. Herb.); on cliffs of Cow Creek Mountains, Douglas Co., 15 June, 1915, *Cusick 4750* (Mo. Bot. Gard. Herb.); without locality, *W. Lobb 295* (Kew Herb.); "Wahlmet" [probably Willamette], *Tolmie* (Kew Herb.).

Var. **Macounii** (Greene) Greenm. Contr. U. S. Nat. Herb. **11** : 599. 1906; Piper & Beattie, Fl. Northwest Coast, 389. 1915.

S. Macounii Greene, Pittonia **3** : 169. 1897.

S. fastigiatus var. *eroso-dentatus* Greenm. in Herb.

Stems 3 dm. or more high, simple or branched; similar to the species, but with somewhat larger and often coarsely erose-dentate stem-leaves.

Distribution: same range as the species.

Specimens examined:

British Columbia: on rocky slopes of Mt. Benson, 10 July, 1893, *Macoun 555* (Geol. Surv. Canada Herb. and Greene Herb., Univ. of Notre Dame, photograph in Mo. Bot. Gard. Herb.), TYPE; Goldstream, Vancouver Island, 25 July, 1893,

Macoun 554 (Geol. Surv. Canada Herb. and Greene Herb., Univ. of Notre Dame).

Washington: dry rocky places, Mt. Constitution, San Juan Co., 12 July, 1904, *Flett 2743* (Gray Herb.).

Oregon: valley of Columbia River, Oregon Boundary Commission, 1860, *Dr. Lyall* (Kew Herb., Berlin Herb., fragment and tracing in Gray Herb.), *type* of var. *eroso-dentatus;* moist ground, Willamette Valley, near Tangent, 18 June, 1881, collector not indicated (Piper Herb.); Eugene, July, 1895, collector not indicated (Univ. Chicago Herb. at Field Mus. No. 366869).

129. S. umbraculifer Wats. Proc. Am. Acad. **23** : 279. 1888; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902 (originally spelled *umbraculifera*).

An herbaceous perennial, densely white-tomentose throughout; stem simple, erect, 5 to 9 dm. high, rising from a stoutish slightly ascending rootstock; leaves oblong-oblanceolate, 5 to 20 cm. long, .5 to 2.5 cm. broad, apiculate-acute, entire or denticulate, gradually narrowed into a winged petiole, densely and permanently white-tomentose on both surfaces; upper stem-leaves sessile, narrowly oblong-lanceolate; inflorescence a terminal many-headed corymbose cyme; heads about 1 cm. high, radiate; involucre campanulate, calyculate; bracts of the involucre about 13, linear-lanceolate, 6 to 7 mm. long and, as well as the bracteoles, terminated by a brownish tip; ray-flowers 5 to 8, rays yellow, conspicuous; disk-flowers 14 to 20; achenes hispidulous.

Distribution: northern Mexico.

Specimens examined:

Chihuahua: summits of the Sierra Madre, alt. 2950 m., 3 Oct., 1887, *Pringle 1316* (Gray Herb., U. S. Nat. Herb., and Phil. Acad. Nat. Sci. Herb.), TYPE.

130. S. atratus Greene, Pittonia **3** : 105. 1896; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902; Rydb. Fl. Colo. 395. 1906; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 580. 1909, in

part; Daniels, Univ. Mo. Studies, Sci. Ser. **2**: 399 [251]. 1911; Wooton & Standley, Contr. U. S. Nat. Herb. **19**: 746. 1915. Pl. 6.

S. exaltatus var. *minor* Gray, Mem. Am. Acad. N. S. **4**: 108. 1849, as to plant of Fendler; Am. Jour. Sci. II. **33**: 238. 1862.

S. lugens var. *exaltatus* Eaton in Bot. King's Exp. 188. 1871, mainly; Porter & Coulter, Fl. Colo. 80. 1874, not *S. exaltatus* Nutt.

S. lugens var. *foliosus* Gray, Bot. Calif. **1**: 413. 1876; Syn. Fl. N. Am. **1**^{2}: 388. 1884, and ed. 2, 1886; Coulter, Manual Rocky Mountain Region, 209. 1885.

An herbaceous perennial, white floccose-tomentose throughout; stems erect or nearly so, 2 to 6 dm. high, from an ascending stoutish rootstock, rather leafy; basal and lower stem-leaves oblong-obovate to oblanceolate, narrowed below into a winged petiole, including the petiole .5 to 3 dm. long, 1.5 to 5.5 cm. broad, mucronate-acute, subentire to sinuate-dentate, permanently floccose-tomentose on both surfaces; upper stem-leaves sessile, lanceolate, usually becoming smaller towards the terminal compound corymbose or round-topped cyme; heads numerous, 10 to 12 mm. high, radiate; involucre narrowly campanulate or somewhat cylindrical, calyculate with a few setaceous bracteoles; bracts of the involucre commonly 8, linear-oblong to linear-lanceolate, 6 to 7 mm. long, obtusish and, as well as the bracteoles, conspicuously black-tipped; ray-flowers 4 or 5, rays yellow; disk-flowers 8 to 12; achenes glabrous.

Distribution: Colorado and Utah, south to New Mexico.

Specimens examined:

Colorado: head-waters of Clear Creek, and the alpine ridges lying east of "Middle Park," coll. of 1861, *Parry 23* (Gray Herb. and Mo. Bot. Gard. Herb.); Lat. 39–41°, coll. of 1862, *Parry 325* [*23*] (U. S. Nat. Herb. No. 349248); Lat. 39–41°, coll. of 1862, *Hall & Harbour 325* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); James Peak, 20 Aug., 1870, *Greene 223* (Gray Herb.); high mountains, Lat. 40–41°, alt. 3050–3655 m., Powell's Colo. Expl. Exp., 1868, *Vasey 335* (Gray Herb.); below Gray's Peak, 10

Aug., 1871, *Geo. Smith* (Phil. Acad. Nat. Sci. Herb.); Gray's Peak, 31 Aug., 1884, *Benj. H. Smith* (Phil. Acad. Nat. Sci. Herb.); Georgetown, alt. 2590 m., 19 July, 1892, *Crandall* (Mo. Bot. Gard. Herb.); mountain sides, near Empire, alt. 3050–3350 m., Aug.–Sept., 1892, *Patterson 252* (Gray Herb. and Mo. Bot. Gard. Herb.); Mosquito Gulch, alt. 3050 m., Hayden's U. S. Geol. Survey, 15 July, 1873, *J. M. Coulter* (U. S. Nat. Herb.); Graymont, 23 July, 1885, and near Graymont, alt. 3350 m., 26 July, 1886, *Letterman* (Mo. Bot. Gard. Herb.); Graymont, 9 Aug., 1888, *Holway* (U. S. Nat. Herb.); Tolland, alt. 2740 m., 5 July, 1913, *Overholts* (Mo. Bot. Gard. Herb.); Argentine Pass, 17 July, 1886, *ex Herb. Trelease* (Mo. Bot. Gard. Herb.); Breckenridge, coll. of 1892, *F. Wislizenus 1065* (Mo. Bot. Gard. Herb.); mountain side, Ida Bell Mine, Summit Co., alt. 3500 m., 8 Aug., 1917, *Clokey 2910* (I. W. Clokey Herb. and Mo. Bot. Gard. Herb.); near Breckenridge, alt. 3350 m., Aug., 1901, *Mackenzie 297* (Mo. Bot. Gard. Herb.); Red Cliff, Eagle Co., 17 July, 1902, *Osterhout 2702* (Phil. Acad. Nat. Sci. Herb.); Como, alt. 3050 m., 25 July, 1897, *Crandall 3079* (U. S. Nat. Herb.); Como, 1 Aug., 1895, *Crandall & Cowen 289* (U. S. Nat. Herb.); Twin Lakes, Wheeler's Expl. and Surv. west of the 100th Meridian, July, 1873, *Wolf & Rothrock 567* [*575*] (U. S. Nat. Herb. and Gray Herb.); vicinity of Twin Lakes, July–Aug., 1902, *C. Juday* (U. S. Nat. Herb.); pine woods, Mt. Princeton, alt. 3350 m., 22 July, 1892, *Sheldon 170, 489* (U. S. Nat. Herb.); Clover Mountain, above Garfield, alt. 3500–3640 m., 31 July, 1910, *Eggleston 6090, 6096, 6105* (U. S. Nat. Herb.); Sangre de Cristo Range, coll. of 1873, *Brandegee 719* (Mo. Bot. Gard. Herb.); Marshall Pass, alt. 3050 m., 19 July, 1901, *C. F. Baker 525* (Gray Herb., U. S. Nat. Herb., Greene Herb., Univ. of Notre Dame, and Mo. Bot. Gard. Herb.); Cochetopa National Forest, 29 Aug., 1912, *S. E. Piper* (U. S. Nat. Herb.); Little Ouray Mountain, 3 Sept., 1896, *E. L. Greene* (Greene Herb., Univ. of Notre Dame); mountains above Ouray, alt. 3655 m., 10 Aug., 1901, *C. F. Baker 756* (Gray Herb., Greene Herb., Univ. of Notre Dame, U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Ridgeway, 18 July, 1917, *Payson 1085* (Mo. Bot. Gard. Herb.); Telluride, alt. 3655 m.,

Aug., 1894, *Tweedy 352* (U. S. Nat. Herb.); in rocky places, La Plata Cañon, alt. 2740 m., 11 July, 1898, *Baker, Earle & Tracy 524* (Gray Herb., Greene Herb., Univ. of Notre Dame, U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); dry sandy soil in open timber, without definite locality, coll. of 1884, *Sheldon* (U. S. Nat. Herb. No. 49303).

Utah: Manti Cañon, alt. 2440 m., 3 Aug., 1895, *M. E. Jones* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); stony places, Mt. Peale, La Sal Mountains, alt. 3050–3350 m., Aug., 1899, *Purpus 7004* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

New Mexico: Valley of Santa Fé Creek, coll. of 1847, *Fendler 437* [*477*] (Phil. Acad. Nat. Sci. Herb.); San Antonio Mountains, Sept., 1867, *Parry* (Gray Herb. and Mo. Bot. Gard. Herb.); Baldy, 4 Aug., 1910, *Wooton* (U. S. Nat. Herb.).

Var. **milleflorus** (Greene) Greenm. comb. nov.

S. milleflorus Greene, Pittonia **4**: 116. 1900; Rydb. Fl. Colo. 395. 1906; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 580. 1909, in synonymy.

S. lugens var. *exaltatus* Eaton, Bot. King's Exp. 188. 1871, in part, i. e. Watson's No. 663.

Heads narrowly campanulate or subcylindrical; involucral bracts somewhat narrower than in the species and but slightly or not at all black-tipped; ray-flowers commonly 3; disk-flowers about 7; achenes glabrous.

Distribution: southern Colorado and Utah.

Specimens examined:

Colorado: Pagosa Springs, 27 July, 1899, *C. F. Baker 711* (Greene Herb., Univ. of Notre Dame, Gray Herb., U. S. Nat. Herb., Berlin Herb., and Mo. Bot. Gard. Herb.), TYPE; Pagosa Springs, alt. 2135 m., 15 July, 1893, *Benj. H. Smith* (Phil. Acad. Nat. Sci. Herb.).

Utah: in clefts of rocks, Mt. Millicent, Big Cottonwood Cañon, Salt Lake Co., alt. 2865 m., 28 July, 1905, *Garrett 1522* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); Bear River Cañon, Uintas, alt. 3050 m., U. S. Geol. Expl. of the 40th Parallel, Aug., 1869, *Watson 663* (Gray Herb. and U. S. Nat. Herb.).

131. S. sphaerocephalus Greene, Pittonia **3** : 106. 1896; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32** : 20. 1902; Blankinship, Mont. Agr. Coll. Sci. Studies **1** : 102. 1904.

S. altus Rydb. Mem. N. Y. Bot. Gard. **1** : 443. 1900; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains, 580. 1909.

An herbaceous perennial, floccose-tomentulose throughout; stems erect, 3 to 8 dm. high, from a horizontal or ascending stoutish rootstock, simple or sparingly branched, striate, rather leafy at the base, nearly naked above; radical and lower stem-leaves oblong-obovate to oblanceolate, 5 to 25 cm. long, 1 to 3.5 cm. broad, acute or obtuse, entire or shallowly sinuate-denticulate, gradually narrowed below the middle into a winged petiole, white floccose-tomentulose on both surfaces and, as well as the stem, somewhat glabrate; upper stem-leaves few, rather remote, sessile, lanceolate, the uppermost bracteiform; inflorescence a terminal rather close, few to several-headed corymbose cyme; heads about 1 cm. high, radiate; involucre broad-campanulate, calyculate, tomentulose to nearly glabrous; bracts of the involucre usually about 21, linear-lanceolate, 5 to 6 mm. long, pale green or occasionally somewhat tinged with purple and, as well as the bracteoles, brownish or black-tipped; ray-flowers 8 to 13, rays yellow; disk-flowers 40 to 60; achenes hispidulous.

Distribution: Montana to Colorado, west to Idaho and Nevada.

Montana: Spanish Basin, Madison Range, 17 July, 1896, alt. 1830 m., *Flodman 912* (Mo. Bot. Gard. Herb.); Spanish Basin, Gallatin Co., alt. 1980 m., 1 July, 1897, *Rydberg & Bessey 5258* (N. Y. Bot. Gard. Herb., Greene Herb., Univ. of Notre Dame, Gray Herb., U. S. Nat. Herb., Mont. Agr. Coll. Herb., photograph in Field Mus. Herb. and Mo. Bot. Gard. Herb.), *type* of *S. altus* Rydb.; Spanish Basin, 25 Aug., 1899, *Blankinship* (Gray Herb.); head of Brackett Creek, Bridger Mountains, alt. 2130 m., 16 July, 1902, *Blankinship* (Gray Herb.); Shield's River, Park Co., 20 July, 1902, *Blankinship* (Gray Herb.); Cottonwood Creek, Tobacco Root Range, alt. 2740 m.,

10 Aug., 1902, *Blankinship* (Gray Herb.); above Elliston, 5 Aug., 1889, *E. L. Greene* (Greene Herb., Univ. of Notre Dame).

Yellowstone National Park: Yellowstone Lake, Hayden's U. S. Geol. Survey, 1872, *J. M. Coulter* (U. S. Nat. Herb.); without definite locality, 3 Aug., 1885, *Letterman* (Mo. Bot. Gard. Herb.); Swan Lake Valley, alt. 2195 m., 14 July, 1888, *Knowlton* (U. S. Nat. Herb. and Greene Herb., Univ. of Notre Dame); without definite locality, 12 Aug., 1893, *Rose 179* (U. S. Nat. Herb.); damp woods, near Mammoth Hot Springs, alt. 2130 m., Aug., 1893, *Burglehaus* (U. S. Nat. Herb.); Upper Geyser Basin, 12 July, 1899, *Blankinship* (Gray Herb.); Lower Geyser Basin, 13 July, 1899, *Blankinship* (Gray Herb.); in a bog, Junction Butte, 15 July, 1899, *A. & E. Nelson 5889* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); without definite locality, 13 July, 1902, *E. A. Mearns 1773* (U. S. Nat. Herb.); Swan Lake Flat, 29 July, 1902, *E. C. Sheldon 296* (U. S. Nat. Herb.); without definite locality, 5 Aug., 1902, *Mearns 2862* (U. S. Nat. Herb.).

Wyoming: Union Peak, Wind River Mountains, 12 Aug., 1894, *A. Nelson 1002* (Gray Herb.); Union Peak, Wind River Mountains, alt. 2740 m., 13 Aug., 1894, *A. Nelson 999* (Gray Herb.); Dome Lake, 17 July, 1896, *A. Nelson 2379* (Gray Herb. and Mo. Bot. Gard. Herb.); Granite Creek, Big Horn Mountains, alt. 2740 m., 27 July, 1900, *J. G. Jack* (Gray Herb.); moist meadows, Doyle Creek, Big Horn Co., 26 July, 1901, *Goodding 362* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); without definite locality or date of collection, *Tweedy* (U. S. Nat. Herb. No. 49338).

Colorado: Graymont, 23 July, 1885, *Letterman* (Mo. Bot. Gard. Herb.).

Idaho: grassy stream-banks, Mackay (Bear Cañon), Custer Co., 31 July, 1911, *Nelson & Macbride 1436* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); moist meadow, Alturas Lake, Blaine Co., alt. 1950 m., 12 Aug., 1916, *Macbride & Payson 3722* (Mo. Bot. Gard. Herb.).

Utah: Stillwater Cañon, Bear River, alt. 2590 m., 1 Aug., 1902, *Pammel & Blackwood 4290* (Mo. Bot. Gard. Herb.).

Nevada: "at the watering place and crossing of Humboldt River," coll. of 1872, *A. Gray* (Gray Herb.); Clover Mountains, 26 July, 1893, *E. L. Greene*, and at Deeth, 14 July, 1896, *E. L. Greene* (Greene Herb., Univ. of Notre Dame, Nos. 48047, 48048, and 48049).

(To be continued.)

Explanation of Plate

PLATE 4

Fig. 1. *Senecio neo-mexicanus* Gray
New Mexico

From type specimen, Wright No. 1415, in the Gray Herbarium of Harvard University.

Fig. 2. *Senecio Hallii* Britton
Yellowstone National Park

From specimen collected by "C. R." in the Shoshone Geyser Basin, now in the Gray Herbarium of Harvard University.

GREENMAN — MONOGRAPH OF SENECIO

EXPLANATION OF PLATE

PLATE 5

Senecio loratifolius Greenm.
Mexico

From type specimen, Pringle No. 13676, in the Gray Herbarium of Harvard University.

GREENMAN — MONOGRAPH OF SENECIO

COCKAYNE, BOSTON

Explanation of Plate

PLATE 6

Senecio atratus Greene

From specimen collected by C. S. Crandall at Georgetown, Colorado, 19 July, 1892, now in the Herbarium of the Missouri Botanical Garden.

GREENMAN — MONOGRAPH OF SENECIO

COCKAYNE, BOSTON

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CORRELATION OF THE STRENGTH AND DURABILITY OF SOUTHERN PINE

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INTRODUCTION

It has been known for some time that the strength of pine structural timbers is a function of specific gravity (density). About twenty-five years ago Johnson[1] demonstrated by actual tests on longleaf pine (*Pinus palustris*) that there is a regular increase in average strength with an increase in density, and this is especially true where all of the pieces tested are reduced to a standard dryness. He also pointed out that compression endwise tests parallel with the grain give the best indication of the general strength value of the wood.

Since these earlier studies many testing laboratories have continued to establish relations between the physical and mechanical properties of wood. This is especially true of the Forest Products Laboratory maintained by the United States Forest Service and the Purdue University Laboratory for Testing Materials. The results of the tests made by the Forest Service and others were discussed by Betts[2] before the American Society for Testing Materials, and rules for grad-

[1] Johnson, J. B. Timber physics. Investigations on longleaf pine. 4. Results on mechanical tests. U. S. Dept. Agr., For. Div. Bul. 8: 22–31. *f. 11–16.* 1893.

[2] Betts, H. S. Discussion of the proposed Forest Service rules for grading the strength of southern pine structural timbers. Proc. Am. Soc. for Testing Materials 15[1]: 369–384. *f. 1–9.* 1915.

ing the strength of southern pine structural timbers based on these various investigations were proposed. In general, these tests showed that as the density increases, the strength also increases in a uniform manner, and the density can be estimated by making use of the proportion of summer wood to spring wood in the annual rings. As the density is dependent on the summer wood, the percentage of summer wood is an index of weight and strength, and is an important guide in judging the quality of timber, independent of any defects it may contain. Tests made on pieces of summer wood and spring wood whittled out separately from broad rings of loblolly pine show that the strength and density of the summer wood is very close to double that of the spring wood. Thus there is a definite relation between strength and density of pine timbers.

In a recent paper the writer[1] reported results of experiments in which some important physical properties of southern pine woods were correlated with the decay induced by *Lenzites saepiaria*. Some of these results show that the specific gravity (density) of the wood materially influences resistance to decay of the heart-wood, the more dense pieces being more durable. By the correlation of the function which specific gravity of wood has thus been shown to play in its strength and durability, one would naturally conclude that when a timber possesses properties to make it strong, the chances are that it will be correspondingly durable. Although such inferences might be made, it was thought well to report the results of studies made on the resistance to fungous decay of timbers which had actually been tested for strength. The results of these experiments are reported below.

METHODS OF EXPERIMENTATION

Twelve samples each of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*) were procured, the longleaf pine from the Industrial Lumber Company, Elizabeth,

[1] Zeller, S. M. Studies in the physiology of the fungi. III. Physical properties of wood in relation to decay induced by Lenzites saepiaria Fries. Ann. Mo. Bot. Gard. **4**: 93–164. *pl. 9–13. f. 1. Charts I–XI.* 1917.

Louisiana, and the shortleaf pine from the Missouri Land and Lumber Company, West Eminence, Missouri. All of the samples were 4×4 inches, and each was sawed into two pieces, one of which was sent to the Laboratory for Testing Materials at Purdue University, and the other one retained for use in the preparation of culture blocks. The shortleaf pine samples were numbers 46–57, and the longleaf pine, 58–69, the cross-sections being shown in plates 7 and 8, respectively. The same methods of labeling culture blocks, kiln-drying, taking volumes, etc., were used here as were previously reported.[1] In this work the culture blocks were 1×1×2 inches. Four columns, A, B, C, and D, of five blocks each were used. The position of these in the original samples is shown in the plates.

The culture blocks were placed on end in wide-mouthed quart jars containing about one inch of pine sawdust. Then sawdust was loosely packed around the blocks and moistened with distilled water. The jars were plugged and sterilized as usual, and then the cultures were inoculated with *Lenzites saepiaria*. In this condition they were incubated for 6 months at room temperature. After this time it was apparent that they were not doing as well as in previous experiments where the blocks were not placed in sawdust, and the blocks were therefore removed, piled loosely in a clean pine box, and each layer inoculated anew with *Lenzites saepiaria* grown on pine sawdust. The whole was covered with a layer of damp sawdust which was slightly moistened from time to time. This box was stored in a humid rotting-pit for one year, making a total incubation period of 18 months. After this the blocks were removed, dried and weighed, and the percentage loss in weight during incubation is the index of decay used in plotting the curves shown in figs. 1, 2, and 3.

Strength Tests

A portion from each of the original samples was tested for strength at the Laboratory for Testing Materials, Purdue University. One specimen 6 inches in length from each 4×4-

[1] Zeller, S. M. *Loc. cit.* p. 102.

inch piece was soaked in water for a period of nine weeks. Another specimen 6 inches in length was cut into two sets of four smaller test pieces approximately $1\frac{7}{8}\times1\frac{7}{8}\times3$ inches. One of these sets of smaller test specimens, comprising an entire cross-section of the original piece, was stored in wet shavings for a period of nine weeks. The other set was allowed to come to as uniform a moisture content as possible when stored in ordinary outside air, these being later referred to as air-dry specimens.

All specimens were tested by compression pressure endwise, the load being applied in a direction parallel to the grain of the wood. The maximum crushing load was obtained in each case and is given in table 1. The moisture content of all specimens was obtained by drying to a constant weight at approximately 210° F.

In the small wet blocks the moisture had thoroughly permeated the wood fiber, and the strength was more nearly coincident with the intrinsic strength of the timber as would have been given by tests of the specimens in a green condition. It also seems that the tests of the wet blocks are more indicative of the intrinsic strength of the wood, inasmuch as the air-dry pieces have non-uniform moisture distribution under the same atmospheric conditions. This condition would apply also to the absorption of water, except that the time of absorption was long enough to bring all of the pieces to a moisture content well above the fiber-saturation point (as shown by the percentage of moisture given in the table), in which case the tests should show the relative intrinsic strength without regard to the varying per cents of moisture as given.

Table 1 gives the results of both the decay and strength tests. The average percentage loss in weight due to decay was made on the number of heart-wood culture blocks from each sample. There was not enough sap-wood in the samples to be of use in drawing conclusions, thus the results reported here are based on heart-wood alone. However, in previous work[1] it has been shown that sap-wood decays irrespective

[1] Zeller, S. M. *Loc. cit.*

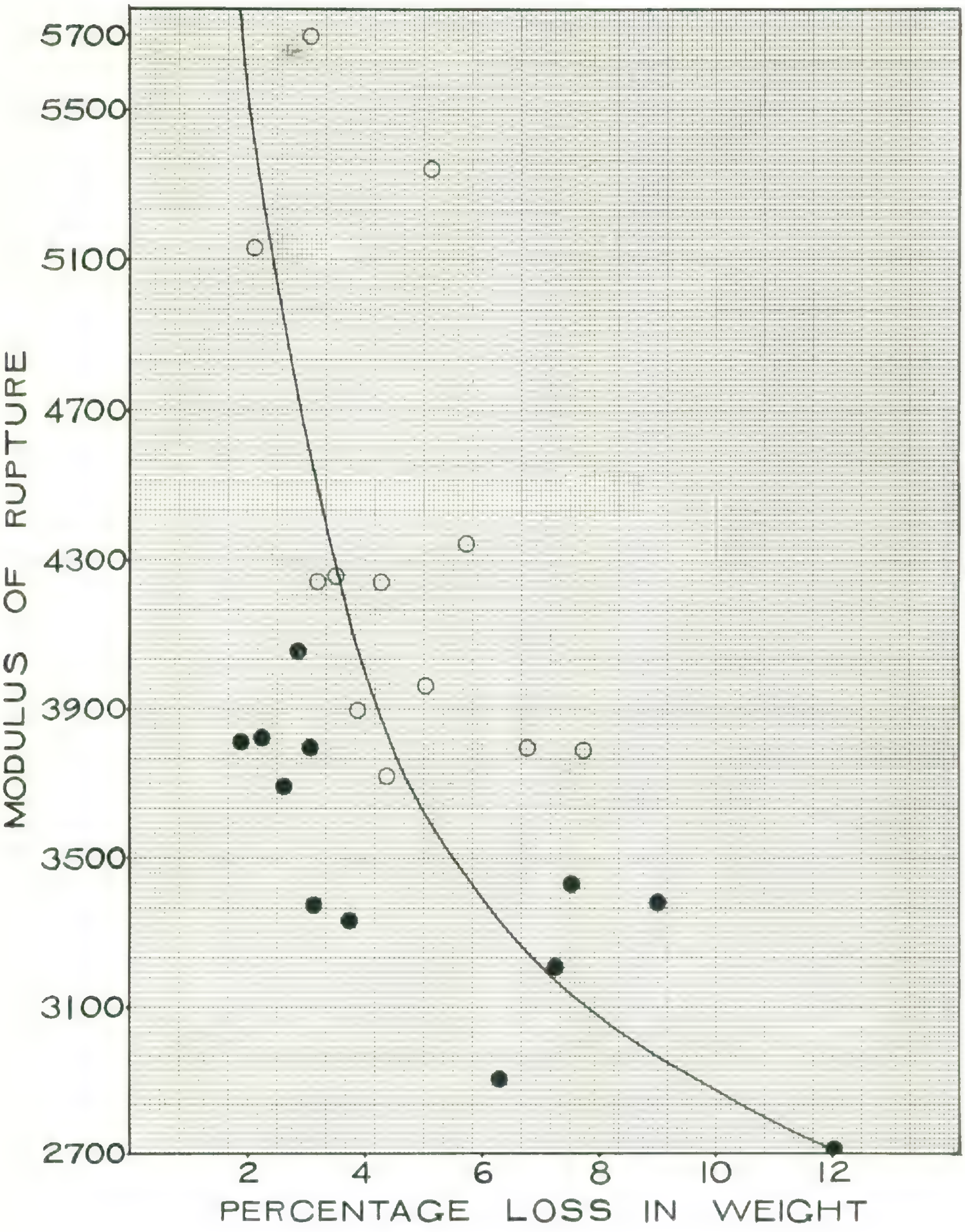


Fig. 1. Showing the relation between strength (when $1\frac{1}{2}\times1\frac{1}{2}$-inch water-saturated blocks were tested) and percentage loss in weight due to the decay of longleaf (○) and shortleaf (●) pine.

of specific gravity or high percentage of summer wood, factors which function in the strength of the pieces.

TABLE I

STRENGTH AND DURABILITY OF SOUTHERN PINE HEART-WOOD

Sample number	Average per cent loss in weight of heart-wood due to decay	Strength tests					
		Small blocks (wet)		Full-size blocks (wet)		Small blocks (dry)	
		Strength in pounds per square inch	Per cent moisture	Strength in pounds per square inch	Per cent moisture	Strength in pounds per square inch	Per cent moisture
Shortleaf pine (*Pinus echinata*)							
46	3.13	3375	58.1	3050	50.7	6052	10.8
47	7.24	3207	63.8	2840	47.8	5080	12.8
48	2.85	4055	61.9	3655	47.4	5765	12.6
49	9.00	3380	47.5	3065	46.3	5962	10.4
50	7.52	3432	55.9	3550	53.9	6447	11.9
51	3.74	3332	40.1	3185	59.1	5605	11.1
52	2.24	3822	50.0	3770	45.4	7277	10.2
53	1.88	3812	50.7	3410	50.1	6142	11.3
54	12.02	2705	82.3	2440	43.6	3957	15.9
55	2.61	3692	67.5	3555	53.8	6160	14.0
56	6.29	2902	79.9	2790	54.0	5202	12.1
57	3.07	3795	56.9	3910	43.6	5817	13.8
Longleaf pine (*Pinus palustris*)							
58	2.11	5130	25.2	5220	25.3	8032	13.5
59	3.19	4255	50.7	4290	41.3	7312	13.1
60	5.12	5340	26.0	5270	24.0	8812	10.6
61	5.72	4342	65.6	3990	58.4	7012	14.5
62	4.26	4240	67.1	4180	53.9	7817	13.5
63	3.06	5695	42.0	5540	40.2	8272	14.0
64	4.37	3720	57.7	3570	47.3	6635	13.1
65	6.76	3795	60.0	3690	56.1	6450	12.3
66	7.73	3790	81.6	4020	64.6	6467	13.7
67	3.50	4257	44.1	4130	39.6	7485	11.2
68	3.87	3897	43.4	3890	45.7	6897	10.3
69	5.03	3962	42.4	3910	46.1	7147	11.3

Results and Conclusions

The curves in figs. 1, 2, and 3 graphically represent the results presented in table 1. Figure 1 shows the relation between strength and durability of pine heart-wood when the strength tests were made on $1\frac{7}{8}\times1\frac{7}{8}$-inch water-saturated blocks. Figures 2 and 3 show the same relation when 4×4-inch water-saturated blocks and $1\frac{7}{8}\times1\frac{7}{8}$-inch air-dry blocks, respectively, were tested for strength. The three strongest samples, 63, 60, and 58, show considerable loss in weight, which is not totally due to decay. They were highly resinous,

and some of the resin was lost in sterilizing under steam pressure. The curves are corrected for this error.

The curves in the three cases show that as the strength increases the durability increases. In order to refer to some specific instances, examine plate 7, showing the cross-sections of the original shortleaf pine samples, and notice numbers 48 and 53 in contrast with numbers 49 and 54. The former show a much higher percentage of dark summer wood and somewhat narrower growth rings in the heart-wood than in the latter. In the table, numbers 48 and 53 show a loss in weight due to decay of 2.85 and 1.88 per cent, respectively, and are relatively strong, while numbers 49 and 54 show a loss in weight from decay of 9 and 12.02 per cent, respectively, and are not nearly so strong as numbers 48 and 53. Other examples, such as contrasting numbers 46 with 56, 52 with 47, etc., will show this same relation of strength and decay. For instance, in plate 8, showing the original samples of longleaf pine, number 63 has narrow rings with a high percentage of summer wood, characters which are conducive to strength, in contrast to number 65, which has broad rings with a low percentage of summer wood. The strength tests show number 63 much stronger than 65, and the decay tests show a loss of 6.76 per cent in number 65 and 3.06 per cent in number 63. The same relation is shown when contrasting numbers 58 with 61, 59 with 64, 60 with 66, etc.

The results thus show that whether we are dealing with shortleaf pine or longleaf pine the stronger pieces of heart-wood are the more durable, and *vice versa*. This, however, does not apply to sap-wood, as it seems to decay irrespective of the amount of summer wood and specific gravity, which materially influence the strength of yellow pine sap-wood.

The writer wishes to express his appreciation to the Missouri Botanical Garden for the use of the laboratories; to the Southern Pine Association for providing funds which made this work possible; and to Dr. Hermann von Schrenk for suggesting this work and for his aid and interest.

Graduate Laboratory, Missouri Botanical Garden.

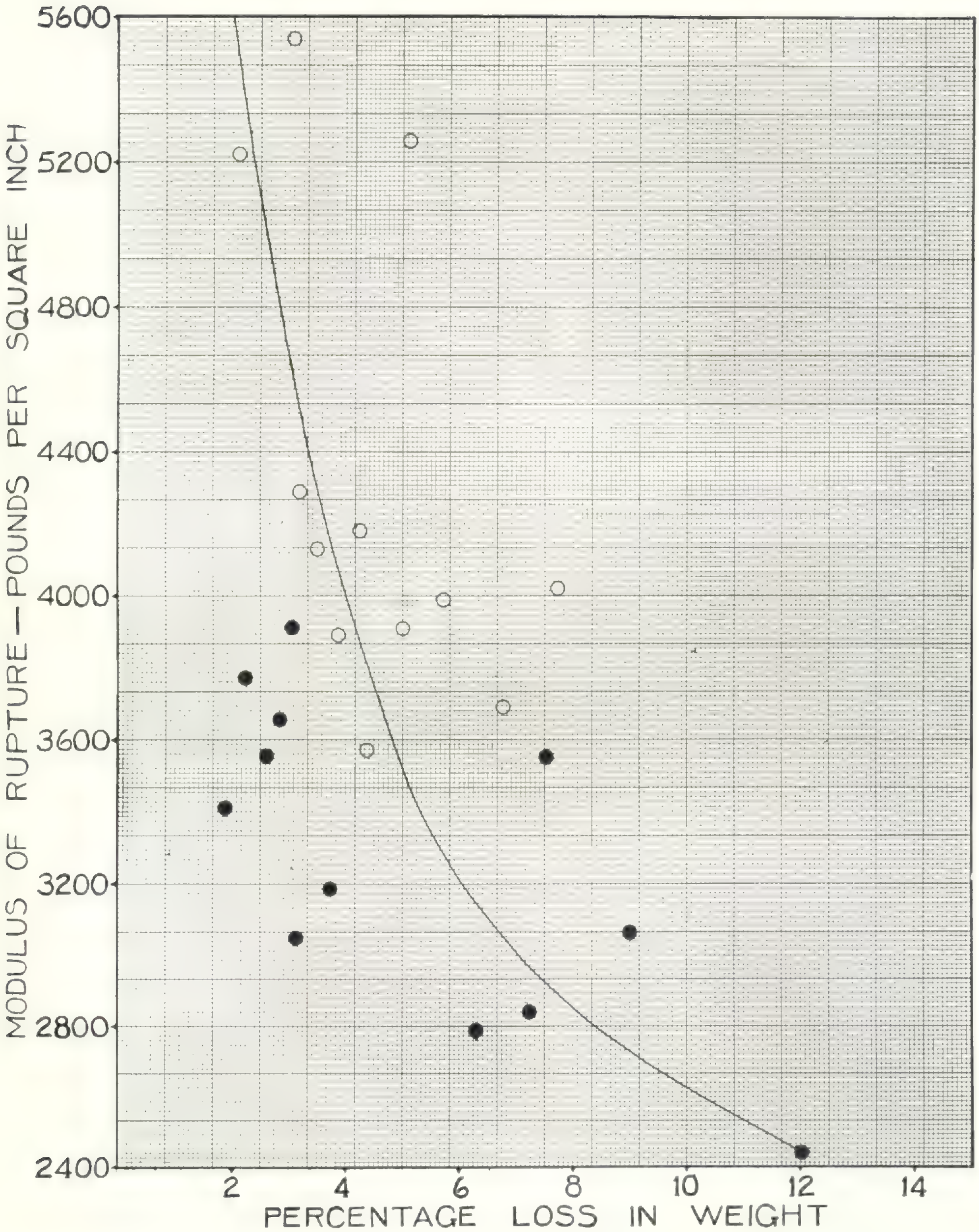


Fig. 2. Showing the relation between strength (when 4×4-inch water-saturated blocks were tested) and percentage loss in weight due to the decay of longleaf (○) and shortleaf (●) pine.

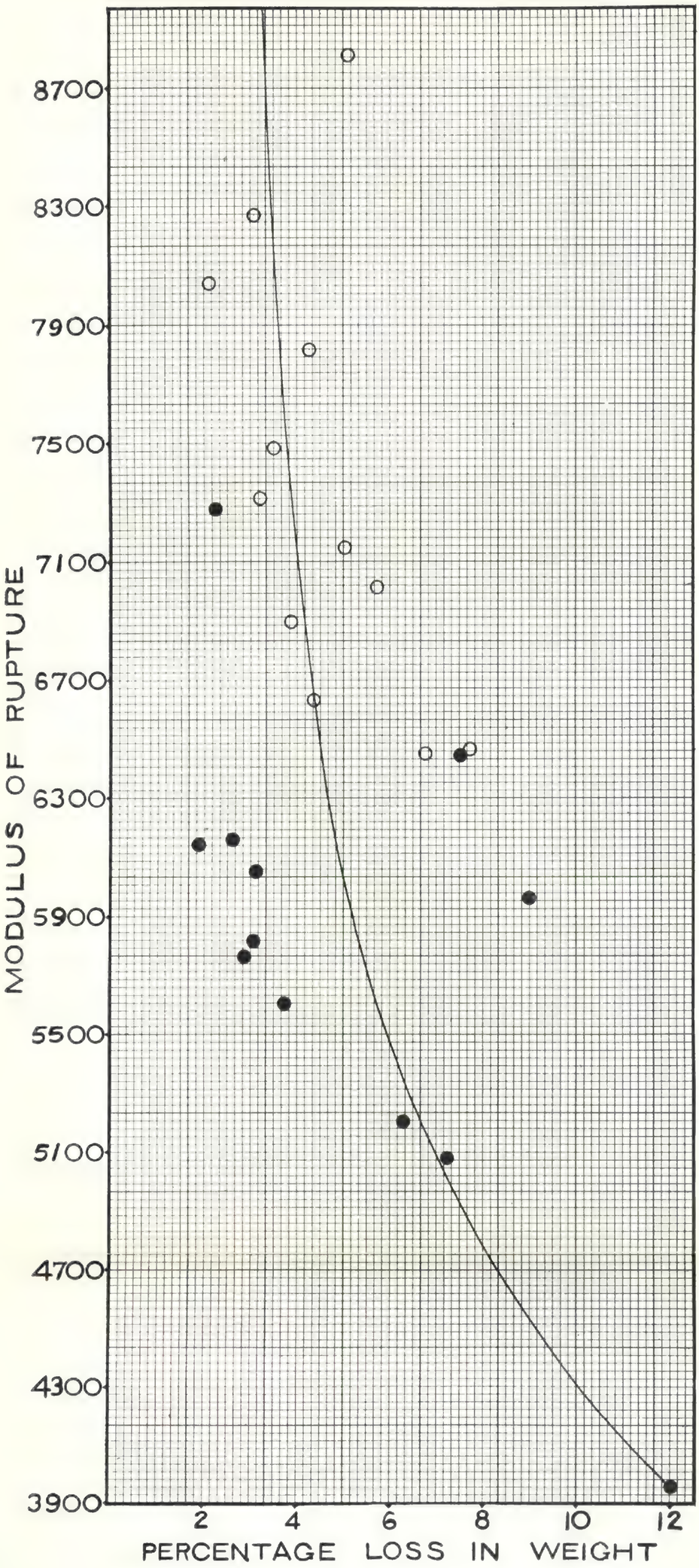
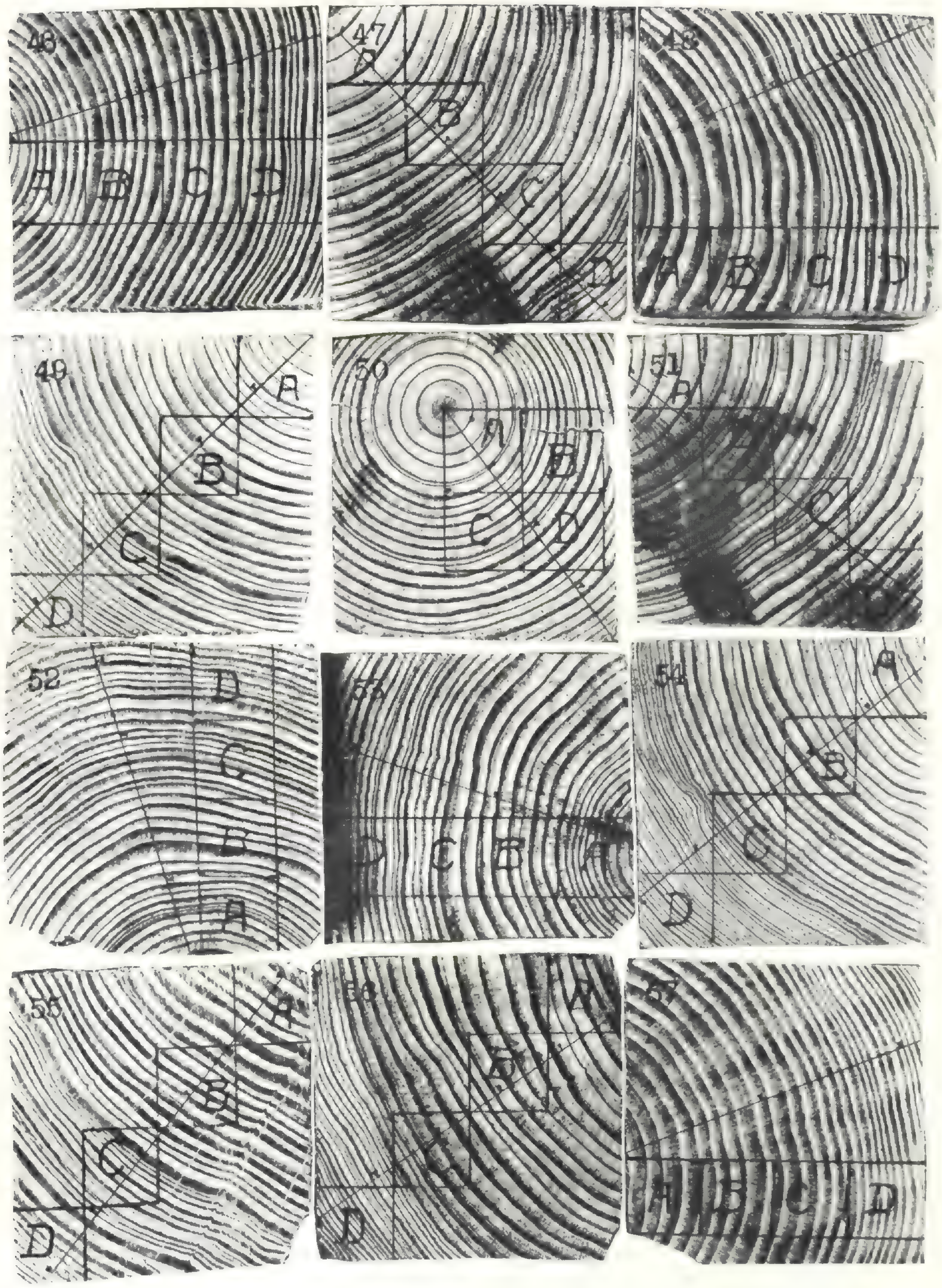


Fig. 3. Showing the relation between strength (when $1\frac{7}{8}\times1\frac{7}{8}$-inch air-dry blocks were tested) and the percentage loss in weight due to the decay of longleaf (○) and shortleaf (●) pine.

EXPLANATION OF PLATE

PLATE 7

The original samples of shortleaf pine (*Pinus echinata*). The lettered squares are 1×1 inch and represent the columns of culture blocks used in the experiments.

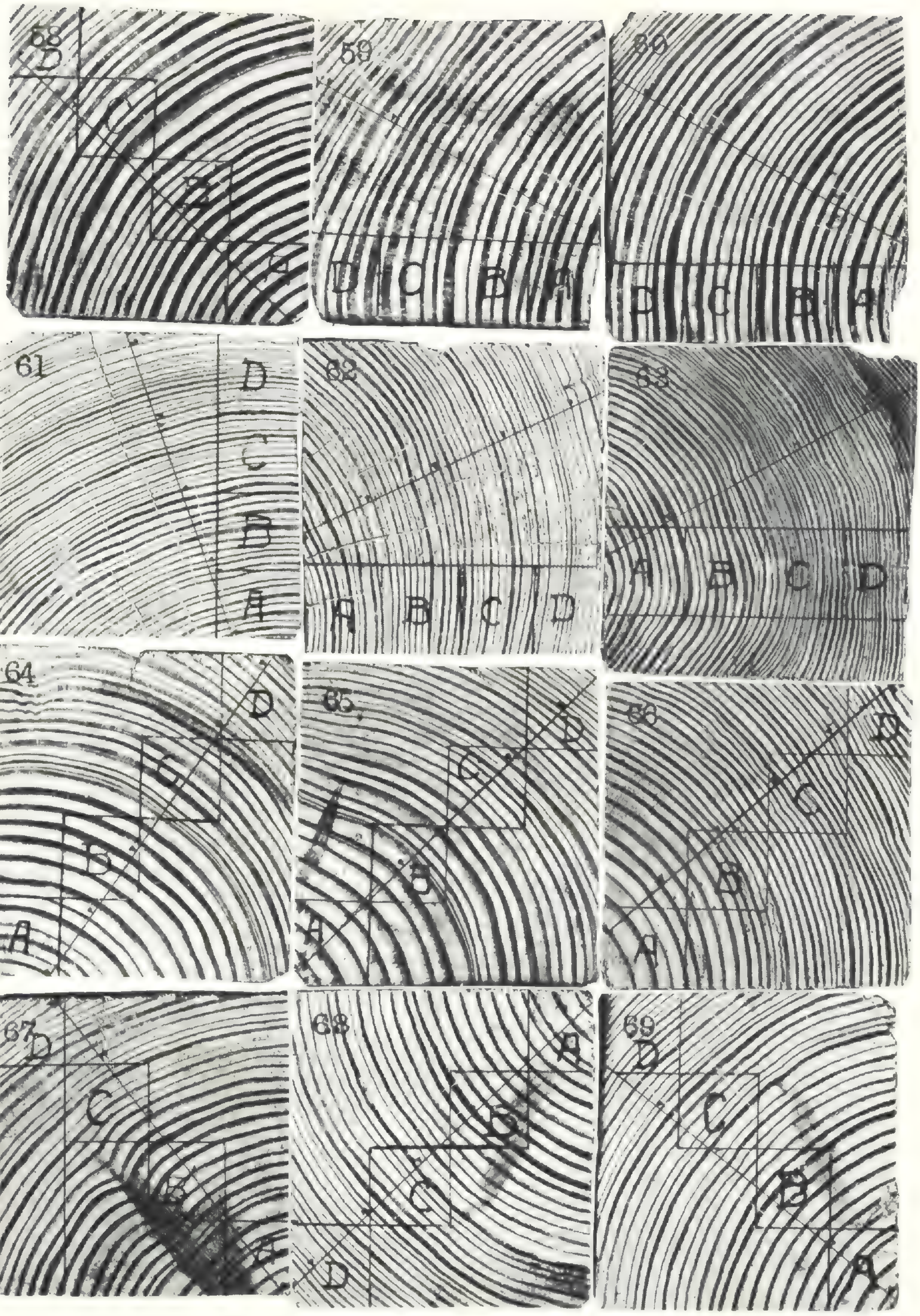


ZELLER—STRENGTH AND DURABILITY OF PINE

Explanation of Plate

PLATE 8

The original samples of longleaf pine (*Pinus palustris*). The lettered squares are 1×1 inch and represent the columns of culture blocks used in the experiments.



ZELLER—STRENGTH AND DURABILITY OF PINE

CORTICIUMS CAUSING PELLICULARIA DISEASE OF THE COFFEE PLANT, HYPOCHNOSE OF POMACEOUS FRUITS, AND RHIZOCTONIA DISEASE[1]

EDWARD ANGUS BURT

Mycologist and Librarian to the Missouri Botanical Garden
Associate Professor in the Henry Shaw School of Botany of Washington University

Last year Professor F. L. Stevens sent to the author specimens of coffee branches collected at Mayaguez, Porto Rico, August, 1915, which were infested with the Pellicularia fungus, and requested that study be made to determine whether this fungus is not one of the *Thelephoraceae*. In compliance with this request, preparations were made from the material, which finally afforded simple basidia bearing hyaline, even spores 12×4 μ, flattened on one side. This fungus is a *Corticium* with habit of growth and structure greatly resembling the *Hypochnus ochroleucus* Noack which Dr. Stevens studied in 1907.

Upon looking up the literature of the Pellicularia fungus complications developed as follows:

1. *Pellicularia koleroga* was published by M. C. Cooke, in 1876, as a hyphomycete having solitary, globose, echinulate spores situated here and there along the sides of the hyphae. In the article in Popular Science Review **15**: 164–165. 1876, Cooke expresses doubt as to whether the globose bodies are spores, because they do not become detached from the hyphae, and believes that their true nature will have to be decided by germination experiments. The material upon which Cooke based his species was collected at Mysore, India.

2. Dr. A. Ernst studied diseases of coffee in Venezuela and published a paper in 1878, entitled "Estudios sobre las Deformaciones, Enfermedades y Enemigos del Arbol de Cafe in Venezuela," pp. 1–24. Caracas. One of the diseases consid-

[1] Issued May 24, 1918.

ered in the paper is named by Ernst as Candelillo, and its fungous cause is described rather fully by him as *Erysiphe scandens,* with an illustration of mycelium bearing conidia. Specimens of coffee leaves affected with "Candelillo" were sent to Kew Herbarium by Ernst; these specimens were studied by Cooke, who determined the fungus as his *Pellicularia koleroga.*

3. In 1912, Kuijper concluded that the fungous leaf blight of coffee in Porto Rico is distinct from that causing Candelillo in Venezuela and different from *Pellicularia koleroga* of India. Shortly afterward G. L. Fawcett obtained through E. J. Butler specimens of the coffee blight fungus from Mysore, the type locality, and concluded that the Porto Rican fungus agreed in every way with that from Mysore, but that the Venezuelan fungus is distinct. Neither of these authors noted the basidiomycetous nature of the fungus which they studied, although it is obvious from the illustration by Fawcett that he figured young basidia as hold-fast cells.

Upon writing to the Kew Herbarium for a fragment of the type of *Pellicularia koleroga* Cooke, in order that I might determine for the systematic account of North American species of *Corticium* the status of the *Corticium* parasitic upon coffee leaves at Mayaguez, the Director of Kew Herbarium kindly presented me with small portions of the Venezuelan specimens which had been received from Ernst and regretted that the Mysore specimen was now so fragmentary that only microscopical preparations from it could be spared. Miss Wakefield very kindly sent with these preparations drawings which she made of the basidia, spores, and hyphae from the above-mentioned preparation as soon as prepared, drawings of the same parts in the Ernst Candelillo specimen, similar drawings and portion of a specimen on coffee collected in Colombia by H. T. Dawe, and other drawings of the same organs based on Trinidad specimens collected by J. H. Hart.

The collections on coffee leaves made by Dr. Stevens and Mr. H. E. Thomas, at Mayaguez, Porto Rico, in August, 1915,

and in May, 1917, respectively, agree with the collections from Venezuela and Colombia in all respects except slight differences as to whether the hyphae are hyaline or slightly colored. In cross-sections of the leaves of all the specimens, fungous hyphae are present more or less abundantly between the cells of the leaf parenchyma and extending across the intercellular spaces of the leaf. Occasionally these hyphae may be traced outward to the under surface of the leaf, where they form a part of the layer, one to three hyphae thick, of hyphae running along the surface of the leaf, sending out branches at nearly a right angle, and forming a membrane about as loosely interwoven as the fructification of the common *Corticium vagum*. These hyphae range from $4\frac{1}{2}$ to 6 μ in diameter and are neither nodose-septate nor incrusted. In the Porto Rican specimens, which have most of their basidia still swollen with protoplasm and only occasionally bearing spores, and are therefore hardly mature, the hyphae are mostly hyaline and show no tinge of color except in the case of those hyphae next to the substratum, where local thickenings of the fructification occur. In the Ernst collection from Venezuela the hyphae when stripped from the leaf are of a very dilute honey-yellow—the honey-yellow of Ridgway greatly diluted. The hyphae of the specimen from Colombia are sometimes hyaline and sometimes with a slight yellowish tint, being about intermediate between the Ernst collections and those from Porto Rico.

Basidia are scattered along the hyphae at right angles to the surface of the leaf. But few basidia are present in the Ernst specimen, which appears to me to be old, and I did not succeed in finding spores in the few preparations which the bit of material permitted. Miss Wakefield found the spores of this collection to be 9–13$\times$3$\frac{1}{2}$–4 μ. The basidia collapse quickly after spore formation.

Nothing in the nature of appressoria for attachment of the fructification to the leaf could be found; the fructification appears to be anchored along the under side of the leaf by the hyphae from the parasitic intercellular vegetative mycelium,

which pass out to the under side of the leaf and there branch, become interwoven and form the membranous fructification.

The spores are very uniform in size and form, hyaline, even, slightly curved, 9–13×3½–4 μ for all American collections, and were published by von Höhnel as 10–12×4–4⅕ μ for the Mysore type, and noted by Miss Wakefield as 10–13×4–5 μ for the latter.

Von Höhnel described Cooke's type of *Pellicularia koleroga* from Mysore as having "Grundhyphen gerade verlaufend, dünnwandig, meist blaszbräunlich, 6 bis 7 μ breit, langgliedrig; . . . . Zweige zartwandig, hyalin, mit aufeinander fast senkrecht stehenden Abzweigungen versehen." Miss Wakefield has noted as hyaline the hyphae of this specimen which she has drawn.

In the comment following the specific description of *Pellicularia koleroga,* Cooke stated, "threads creeping, branched, septate, interwoven into a subgelatinous pellicle which can be stripped from the leaf when moist." The introduction of the word *subgelatinous* was unfortunate and misleading, for it gave the idea of a fructification of the consistency of a tremellaceous fungus or of a gelatinous lichen. If we turn to Popular Science Review **15** : 164, we see that Cooke was led to assume the presence of a gelatinous medium to account for the fact that organs which he regarded and figured as spores—which we now conclude were the basidia—did not float loose in any case from the hyphae upon which they were borne. In all fungi of gelatinous or tremellaceous consistency which the present writer has studied, the gelatinous substance is due to a gelatinous modification of the outer portion of the cell wall of the hyphae concerned, so that only the lumen of the hypha remained sharply defined when observed with the microscope; the cell walls of the hyphae of the type of *Pellicularia koleroga* in the preparations received from Miss Wakefield are not in the least degree gelatinously modified. However, when, in case of other collections, I moisten the fructification on the leaf and detach it from the surface of the leaf with the point of a scalpel, I do detect in

places from along the very surface of the leaf a very delicate transparent membranous structure suggestive of the hypothallus of such a myxomycete as *Stemonitis* but much more tenuous and delicate. It is quite possible that this pellicle is a portion of the surface of the leaf, for it does not show in all preparations. Fawcett, who had the good fortune to be able to compare with Porto Rican material freshly collected specimens of *Pellicularia koleroga* collected by E. J. Butler at the type locality, Mysore, India, stated that the conclusion by Kuijper that the Porto Rican fungus is not *Pellicularia koleroga,* would seem reasonable if the possession of a gelatinous matrix were necessary to make it that fungus, but that the Mysore specimens agreed in every way with those growing in Porto Rico. In his independent redescription, as a *Corticium,* of Cooke's type of *Pellicularia koleroga,* von Höhnel does not employ the word *subgelatinous,* which everything seems to show should never have been used in connection with the fungus under consideration.

This study of the Pellicularia fungus on coffee plants in the tropics of America leads to the conclusion that this fungus is a *Corticium* not specifically distinct from *Corticium koleroga* (Cooke) v. Höhn., and that the description should be broadened slightly to comprehend better the specimens now known from widely separated regions, as follows:

Corticium koleroga (Cooke) v. Höhn. K. Akad. Wiss. Wien Sitzungsber. **119**: 395. 1910.

Pellicularia koleroga Cooke, Grevillea **4**: 116, 134. 1876; Pop. Sci. Rev. **15**: 164. *pl. 135. f. a–c.* 1876; Linn. Soc. Bot. Jour. **18**: 461. 1881; Sacc. Syll. Fung. **4**: 149. 1886; Fawcett, G. L., Porto Rico Agr. Exp. Sta. Ann. Rept. **1910**: 35. 1911; Jour. Agr. Res. **2**: 231. *text f. 1–3.* 1914; Porto Rico Agr. Exp. Sta. Bul. 17: 8. *pl. 1.* 1915.—*Erysiphe scandens* Ernst, A., Estudios sobre las Deformaciones, Enfermedades y Enemigos del Arbol de Cafe in Venezuela, 16. *pl. f. 5.* 1878.

Type: in Kew Herb.

The parasitic vegetative mycelium forms long, slender, mycelial strands of rather uniform diameter, whitish or pallid

at first, finally fuscous, running along the branches and midrib and veins of the leaves, infecting the leaves and ramifying between the cells of the leaf parenchyma, finally emerging at many points on the under side of the leaf to form minute fructifications which give a mottled appearance to the leaf; fructifications soon laterally confluent into a thin, arachnoid, perforate membrane covering the under surface of the leaf between midrib and principal veins, drying pale

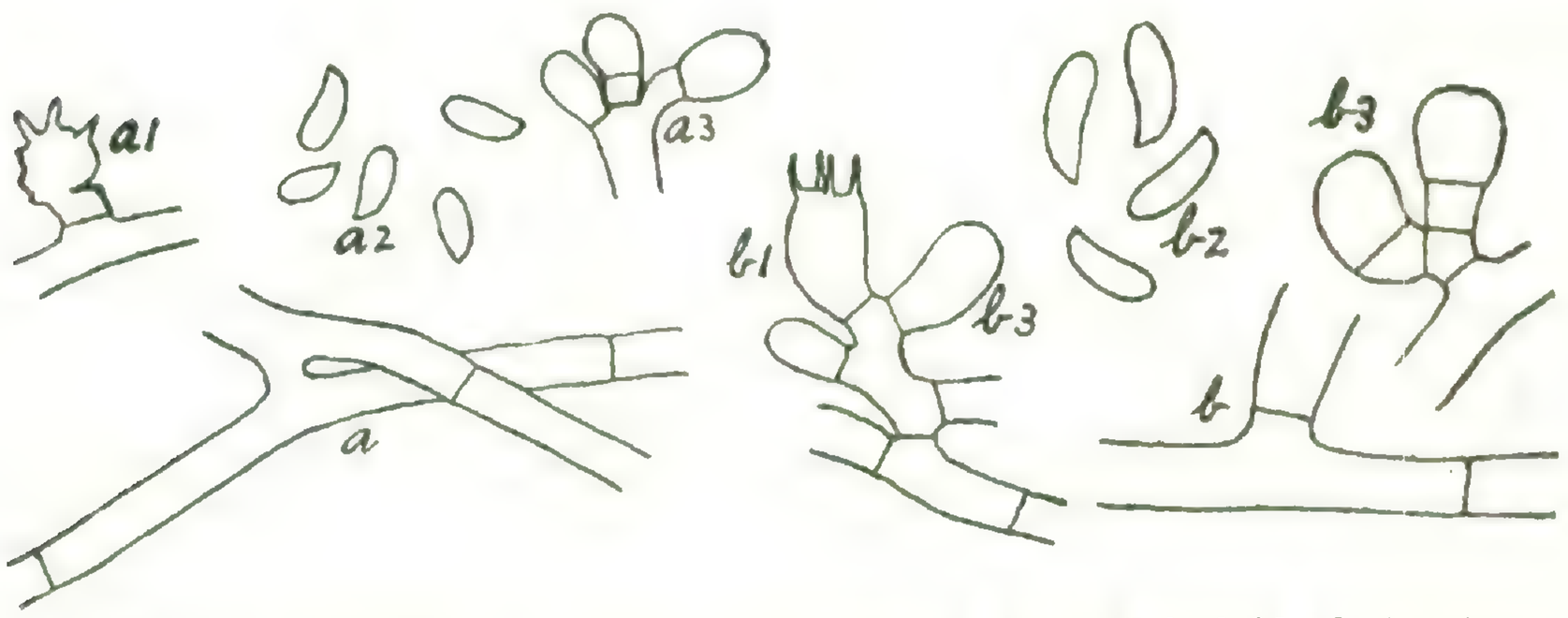


Fig. 1. C. koleroga. *a–a3*, from sketches by Miss Wakefield of structure of type in Kew Herbarium; magnification not stated but computed from spore dimensions at about 630. *a*, hypha; *a1*, collapsed basidium; *a2*, spores; *a3*, young basidia. *b–b3*, from Porto Rican specimen, ×870. *b*, hypha; *b1*, basidium; *b2*, spores; *b3*, young basidia.

smoke-gray, separable in small pieces, composed of loosely interwoven, hyaline or slightly colored, thin-walled, even, rigid hyphae 4½–6 μ in diameter, not nodose-septate, running parallel with the substratum, and about 1–3 hyphae thick, branching at right angles; basidia scattered along the hyphae, simple, ovoid, 10–12×7–8 μ, with short sterigmata; spores hyaline, even, flattened or slightly concave on one side, 10–13×3½–5 μ.

Mycelial strands in the specimens received are 35 cm. long and broken with the branch at the lower end, ½–1 mm. in diameter, not swollen into sclerotia; fructifications 9 cm. long, 4 cm. broad, 30–45 μ thick, more or less divided by the midrib and principal veins.

Parasitic on branches and leaves of the coffee plant. India, and the Antilles and neighboring regions of South America.

Specimens examined:

India: Mysore, preparation from the type (in Kew Herb.).

Porto Rico: Mayaguez, *F. L. Stevens, 9488* (in Stevens Herb. and in Mo. Bot. Gard. Herb., 54510); *H. E. Thomas* (in Mo. Bot. Gard. Herb., 55397).

Colombia: *H. T. Dawe,* fragment (in Mo. Bot. Gard. Herb. from specimen in Kew Herb.).

Venezuela: *A. Ernst,* fragments showing mottled stage and continuous fructification respectively (in Mo. Bot. Gard. Herb. from specimens in Kew Herb., determined by Ernst as Candelillo, *Erysiphe scandens*).

In 1907, Stevens published in Science, p. 724, under the name *Hypochnus ochroleucus* Noack, the preliminary account of a *Corticium* parasitic upon branches and leaves of the apple, pear, and quince, in the southern United States; the detailed, illustrated account of this fungus was published later in Annales Mycologici **7**: 49–59. 1909. This fungus is closely related in general aspect and morphological structure to *Corticium koleroga* but differs sufficiently in some details in the collections which have come under observation so that Miss Wakefield and Professor Stevens agree with me in regarding it as a distinct species. In transferring *Hypochnus ochroleucus* Noack to *Corticium,* it becomes necessary to give the species a new specific name, because there is already a valid *Corticium ochroleucum* Bres. In order to bring this species in sharper contrast with the preceding, I redescribe *H. ochroleucus* and name it as follows:

Corticium Stevensii Burt, n. nom.

Hypochnopsis ochroleuca Noack, Boletim do Instituto Agronomico Sao Paulo em Campinas **9**: 80. 1898.—*Hypochnus ochroleucus* Noack in Sacc. Syll. Fung. **16**: 197. 1902; Stevens, Science N. S. **26**: 724. 1907; Stevens & Hall, Ann. Myc. **7**: 49–59. *text f. 1–8.* 1909.—Not *Corticium ochroleucum* Bresadola, Fungi Tridentini **2**: 58. *pl. 167. f. 2.* 1892.

Vegetative mycelium forms on the twigs roundish or oblong, chestnut-brown sclerotia 3–4 mm. in diameter, and also

slender mycelial strands white when young, becoming chestnut-brown, running along the twigs and petioles to the leaves and fructifying there; fructifications at first downy and barely visible, soon thickening into a dirty pinkish buff, felty membrane covering the whole under side of the leaf and frequently separable from it as a whole by mere handling; hyphae hyaline or slightly colored, giving their color to the fructifications, even, thin-walled, not incrusted, not nodose-septate, $4\frac{1}{2}$–$7\frac{1}{2}$ μ in diameter; basidia scattered along the hyphae on short lateral branches, simple, 11×7–8 μ, with four short sterigmata; spores hyaline, flattened or slightly concave on one side, 8–11×3–4 μ.

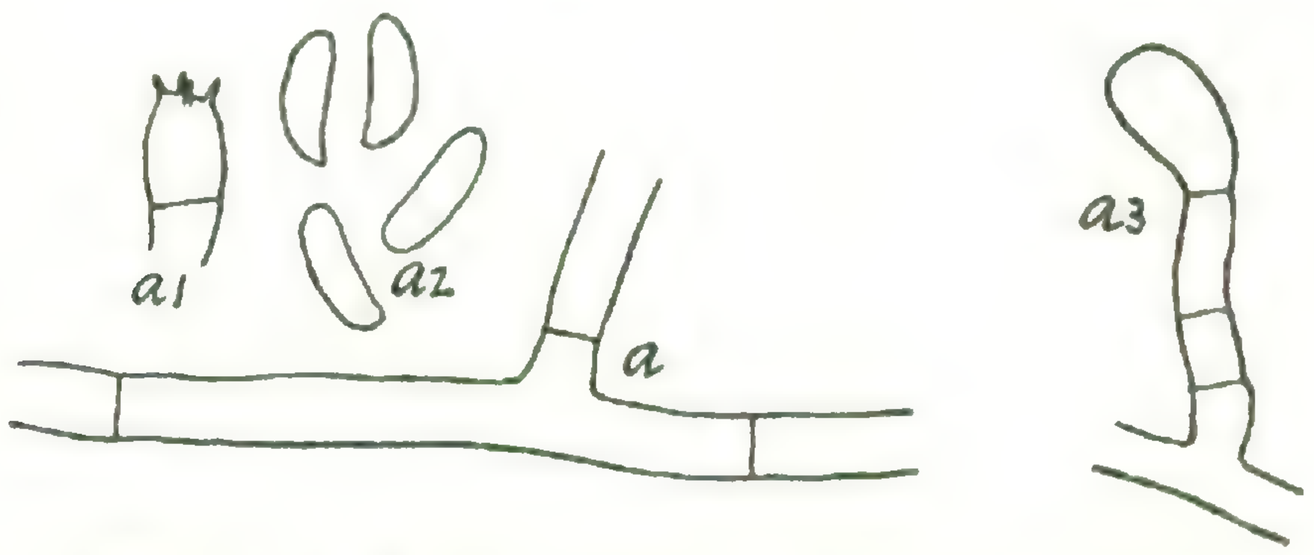


Fig. 2. C. Stevensii. From specimen from Trinidad, ×870. *a*, hypha; *a1*, basidium; *a2*, spores; *a3*, young basidium.

Fructification 11 cm. long, 3–4 cm. broad, 45–60 μ thick, unbroken over whole under surface of leaves; sclerotia 3–4 mm. in diameter; mycelial strands $\frac{1}{2}$–1 mm. in diameter, many cm. long.

On apple, pear, and quince, in Brazil and southern United States, causing the leaves to dry and fall, and on *Codiaeum* in Trinidad.

This species differs from *Corticium koleroga* by having sclerotia and thicker, darker-colored, and more felted fructifications which are but feebly attached to the leaf and form an unbroken covering over the whole under surface of the leaf from margin to margin. Fruiting specimens of this fungus have been available for study from only two localities, but these specimens agree in the characters stated above.

None of the vertical sections of leaves bearing fructifications of *C. Stevensii* have yet shown vegetative hyphae in the intercellular spaces of the leaves, although I have made several sets of preparations expressly for the demonstration of such hyphae. A set of preparations from the petiole of a pear leaf well-coated with the fungus did not show hyphae in the interior of the petiole. Microscopic characters of *C. Stevensii* and *C. koleroga* are within the limits of fluctuation of a single species. In connection with the collections on *Codiaeum* Dr. Rorer wrote, "This thread blight occurs here in the damp valleys every year and takes quite a toll of crotons, nutmegs, and many decorative plants, even roses."

Specimens examined:

North Carolina: Horseshoe, *J. G. Hall,* comm. by F. L. Stevens, sclerotial stage on pear twigs; Mt. Airy, *F. C. Reimer,* comm. by F. L. Stevens, fertile stage on pear leaves.

Georgia: *A. L. Quaintance,* comm. by F. S. Earle, sclerotial stage on apple twigs.

Florida: *C. G. Lloyd,* sclerotial stage on pear twigs.

Texas: Dickson, *F. W. Mally,* comm. by U. S. Dept. of Agr., sclerotial stage on pear twigs.

Trinidad: Diego Martei, *J. B. Rorer,* fertile stage on leaves of *Codiaeum variegatum* (in Mo. Bot. Gard. Herb., 44771); Petit Valley, *J. B. Rorer,* sclerotial and fruiting stages on leafy twigs of *Codiaeum variegatum* (in Mo. Bot. Gard. Herb., 11960, 19786, 19810, and 20062).

Corticium vagum Berk. & Curtis is another parasitic *Corticium,* which belongs in the section with the preceding species by reason of the structure of its fructification. In contrast with the mycelium and sclerotia upon stems of the portions of the host above ground in the preceding species, *C. vagum* has its mycelium saprophytic in the soil and becoming parasitic and sometimes forming sclerotia on subterranean portions of host plants, such as roots or underground stems,—presumably an adaptation to the climatic con-

ditions of the region in which this species lives. The parasitic mycelial stage of *C. vagum* is *Rhizoctonia Solani* Kühn, for full accounts of which and for the literature, reference may be made to the papers by Duggar in Ann. Mo. Bot. Gard. **2** : 424–458. 1915, and Peltier, Univ. of Ill. Agr. Exp. Sta. Bul. 189 : 283–390. 1916. *Corticium vagum* is known to the writer by fruiting specimens ranging in North America from New Brunswick to southern United States and from the Atlantic to the Pacific, and in Europe by specimens from Sweden and Russian Poland. *Rhizoctonia Solani* has been reported from regions, additional to the above, of the West Indies, India, and Australia. *Corticium vagum* is remarkable, not only by the ability of its vegetative mycelium to live as a saprophyte in soil and wood and as a parasite in living plant tissues, but it may come to the surface and fruit on each of these substrata—very commonly indeed on old wood and bark lying on the ground, more rarely on the small stems of potatoes, tomatoes, rhubarb, radishes, beans, *Amaranthus, Plantago,* etc., just above the surface of the ground. I have received only one specimen in which the fructifications were directly on the surface of the ground itself, but the fructification is so inconspicuous when on the ground that it may be easily overlooked. The wide range as to substratum of *C. vagum* has led to its having been described in Europe as *Hypochnus Solani* when collected on potato stems and as *Corticium botryosum* when on old wood. The synonymy and description follow:

Corticium vagum Berk. & Curtis, Grevillea **1** : 179. 1873; Sacc. Syll. Fung. **6** : 616. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 148. 1890; Duggar, Mo. Bot. Gard. Ann. **2** : 445. 1915; Peltier, Univ. of Ill. Agr. Exp. Sta. Bul. 189 : 285. 1915.

Corticium vagum Berk. & Curtis var. *Solani* Burt in Rolfs, Science N. S. **18** : 729. 1903; Colo. Agr. Exp. Sta. Bul. 91 : 1–20. *pl. 1–5.* 1904.—*Hypochnus Solani* Prill. & Del. Soc. Myc. Fr. Bul. **7** : 220. *text f.* 1891; Sacc. Syll. Fung. **11** : 130. 1895.—*Corticium Solani* Prill. & Del. in Bourd. & Galz. Soc. Myc. Fr. Bul. **27** : 248. 1911. — *Corticium botryosum* Bresa-

dola, Ann. Myc. **1** : 99. 1903; Sacc. Syll. Fung. **17** : 173. 1905; Bourd. & Galz. Soc. Myc. Fr. Bul. **27** : 248. 1911.—*Rhizoctonia Solani* Kühn, Krankheiten d. Kulturgewächse, 224. 1858; Duggar, Mo. Bot. Gard. Ann. **2** : 424. 1915.

Type: in Kew Herb. and in Curtis Herb.

Vegetative mycelium saprophytic in the soil and in wood in contact with the ground, and parasitic as the *Rhizoctonia Solani* stage in underground portions of various plants and forming at their surface underground minute sclerotia; fructification a thin, arachnoid, perforate membrane more or

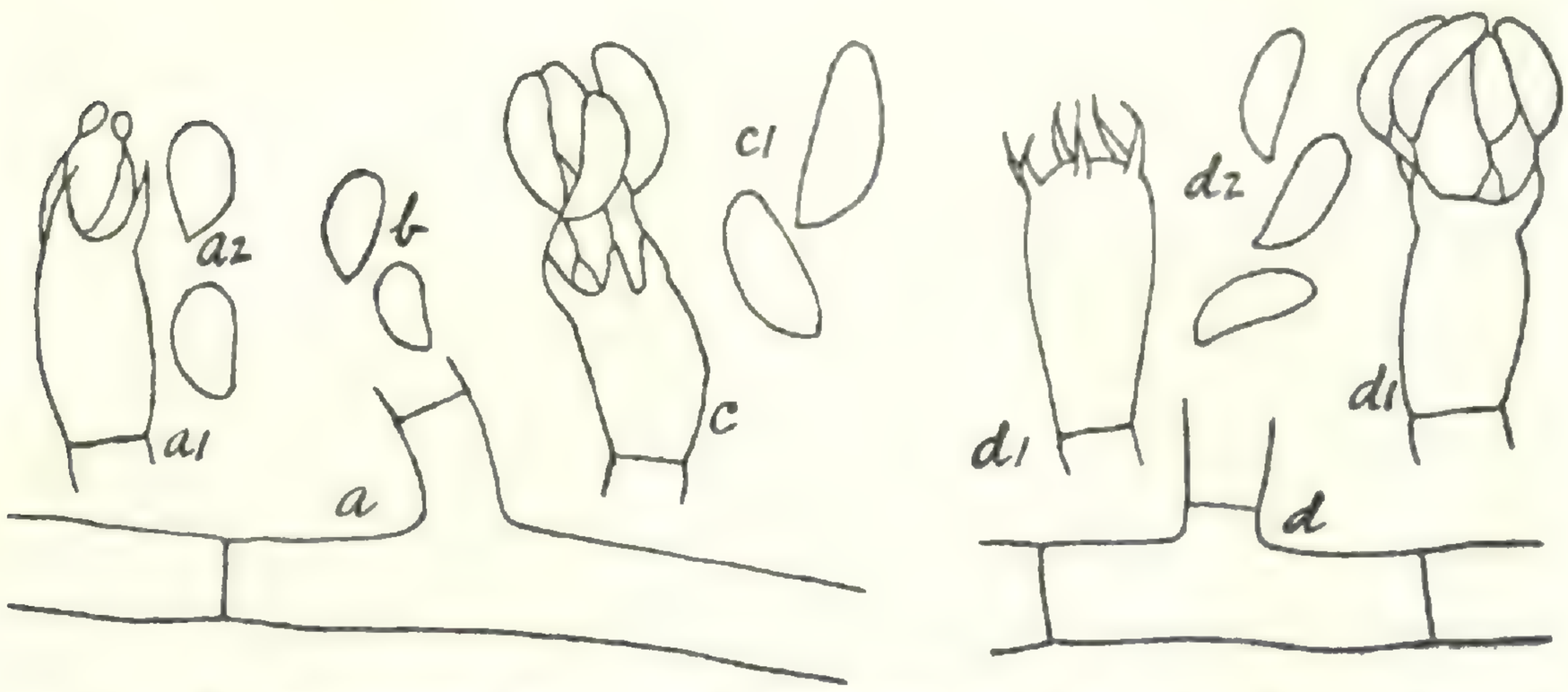


Fig. 3. C. vagum, ×870. *a–a2*, from specimen on potato in Colorado. *a*, hypha; *a1*, basidium; *a2*, spores. *b*, spores of specimen on *Plantago* in Illinois. *c–c1*, from specimen on earth in Massachusetts. *c*, basidium; *c1*, spores. *d–d2*, from specimen on wood in British Columbia. *d*, hypha; *d1*, basidia; *d2*, spores.

less separable, pale olive-buff to cream color; in structure 60–100 μ thick, composed of a few loosely interwoven hyphae running along the substratum and sending out short branches which bear the basidia; hyphae in contact with substratum may be slightly brownish, hyaline elsewhere, not incrusted, not nodose-septate, up to 6–10 μ in diameter, with branches smaller; basidia not forming a compact hymenium, 10–20× 7½–11 μ, with 4–6 sterigmata 6–10 μ long and more or less swollen towards the basidium; spores hyaline, even, flattened on one side, 8–14×4–6 μ.

Fructifications 5–15 cm. long on logs, 5–10 cm. broad; in a collar 1–10 cm. long, sheathing the base of living stems.

On bare earth, wood and bark lying on the ground, and on living stems of potatoes, beans, rhubarb, horseradish, tomatoes, *Amaranthus,* etc., at or near the ground. New Brunswick to Florida and westward to Vancouver and Washington, in West Indies, Europe, India, and Australia. Common.

Corticium vagum differs from *C. koleroga* and *C. Stevensii* in having its mycelium and sclerotia subterranean when parasitic, in having its fructifications at the surface of the ground or merely sheathing small herbaceous stems for only a few centimeters up from the ground and never spreading out on the under side of broad leaves at a considerable distance above ground, by having larger hyphae, larger basidia, and the basidia with larger sterigmata which are more thickened in the lower portion and sometimes six to a basidium; the spores are somewhat larger in *C. vagum* also. The examination of the large amount of *C. vagum* which has come to hand does not afford ground for regarding the collar-like fructifications on small living herbaceous stems as worthy of varietal separation. As common as this species now is in the United States, it is rather surprising that a collection of it under some name has not been found in Herb. Schweinitz.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 330; Ravenel, Fungi Am., 132, 577—the latter under the name *Zygodesmus pannosus.*

Sweden: Stockholm, *L. Romell, 204.*

Russian Poland: *Eichler,* comm. by Bresadola, portion of type of *Corticium botryosum* Bres.

New Brunswick: Campobello, *W. G. Farlow, 3.*

Canada: *J. Macoun, 2, 84, 340.*

Ontario: Ottawa, *J. Macoun, 327.*

Massachusetts: Brookline, *G. R. Lyman, 180;* Magnolia, *W. G. Farlow.*

New York: Albany, *H. D. House & J. Rubinger* (in Mo. Bot. Gard. Herb., 8734); East Galway, *E. A. Burt,* two collections; Ithaca, *Van Hook,* comm. by G. F. Atkinson, 8092; Karner, *H. D. House, 14.162,* and three other collections (in N. Y. State Herb. and Mo. Bot. Gard. Herb., 44709,

54349, 55199, 55203); Tripoli, *S. H. Burnham, 13,* in part (in Mo. Bot. Gard. Herb., 54506).

New Jersey: Belleplain, *C. L. Shear, 1244;* Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 330.

Pennsylvania: Carbondale, *E. A. Burt;* Trexlertown, *W. Herbst, 95.*

Maryland: Takoma Park, *C. L. Shear, 1164, 1334.*

District of Columbia: Takoma Park, *C. L. Shear, 965, 1041* (the former in Mo. Bot. Gard. Herb. also).

South Carolina: Curtis Herb., 3240, type (in Kew Herb. and in Curtis Herb.); Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 132, 577.

Alabama: Montgomery, *R. P. Burke, 170* (in Mo. Bot. Gard. Herb., 43162).

West Virginia: Paw Paw, *C. L. Shear, 1171.*

Ohio: Cincinnati, *C. G. Lloyd, 4508.*

Illinois: Urbana, *G. L. Peltier,* fourteen collections, on living stems of beans, carrot, tomato, radish, rhubarb, horseradish, potato, winter vetch, spinach, *Amaranthus, Campanula,* and *Plantago major* (in Mo. Bot. Gard. Herb., 6264, 8761–8765, 8816, 43836, 44677–44682).

Montana: Evaro, *J. R. Weir, 434* (in Mo. Bot. Gard. Herb., 17725).

Idaho: Priest River, *J. R. Weir, 140, 89* in part (Mo. Bot. Gard. Herb., 8197, 11349).

Colorado: Fort Worth, *F. M. Rolfs,* two collections, on living stems of potatoes.

British Columbia: Sidney, *J. Macoun, 4, 20, 83, 85, 87, 26, 154* (in Mo. Bot. Gard. Herb., 5764, 5735, 7068, 7024, 7833, 55347, 55350, respectively) and *39a, 151, 172* (in Macoun Herb.); Vancouver Island, *J. Macoun, V89, V90, V151, V154, V172* (in Mo. Bot. Gard. Herb., 22815, 22927, 20357, 20507, 20728, respectively).

Washington: Bingen, *W. N. Suksdorf, 846, 852, 863.*

The term "thread blight" has been frequently used in plant pathology with reference to tropical fungi which ascend stems by filamentous, mycelial strands and fructify on the leaves, as in the case of *Corticium koleroga.* Such aërial,

mycelial strands are an adaptation to tropical climate for dispersal, apparently common to many species of fungi of various genera and families. In addition to the specimens of *C. koleroga* and *C. Stevensii,* cited in the earlier pages of this paper, I have seen collections by Mr. J. A. Stevenson, 6498, 6748, 6748a, on *Casearia sylvestris* and *Hippocratea volubilia* from Rio Piedras and Bayamon, Porto Rico, which show soft, white, mycelial strands running along the stems of the host plant to the leaves and not yet fruiting. Dr. F. L. Stevens, 7469, on *Mayepea domingensis,* from Mayaguez Mesa, Porto Rico, has a specimen, with fructifications still too immature for determination, which has spread by an effused mycelium rather than narrow strands for distances of three to four feet along the stems and extends out to leaves along the way. On the living leaves of *Nephrolepsis,* in Porto Rico, Dr. Stevens has a very interesting collection, No. 4380, which has the configuration of a resupinate species of *Hydnum* but has not yet formed basidia and spores. Dr. J. B. Rorer has sent to me from Trinidad photographs of the mycelial strands of the horse-hair blight on the stems of cacao, which seem to be white, cylindric, and compact; he notes that their fructification is usually a polypore.

It is evident that many kinds of fungi in the tropics have the curious "thread blight" habit of growth. One so fortunately placed as to be able to collect such fungi where growing could make sure that the fructifications were mature and of value for taxonomic study by making a spore collection on a glass microscope slide from the fresh specimen.

GAUTIERIA IN NORTH AMERICA[1]

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GAUTIERIA

Gautieria Vittadini, Monogr. Tuberac. 25–27. 1831; Klotzsch in Dietr. Fl. Boruss. (Fl. Königr. Preuss.) **7**: No. 764. *pl. 464.* 1839; Tulasne, Fung. Hypog. 62–63. 1851; Zobel in Corda, Icon. Fung. **6**: 33–34. 1854; Winter in Rabenh. Krypt.-Fl. Deutschl. ed. 2, **1**: 873–874. 1884; DeToni in Sacc. Syll. Fung. **7**: 177–179. 1888; Hesse, Hypog. Deutschl. **1**: 105–110. 1891. —*Gautiera* Endlicher, Gen. Pl. 30. 1836–1840; Corda, Anleit. z. Stud. Myc. 114. 1842; Icon. Fung. **5**: 28. 1842; Rabenhorst, Deutschl. Krypt.-Fl. **1**: 252. 1844; Fries, Summa Veg. Scand. 435. 1849.—Not *Gautiera* Rafinesque, Med. Fl. **1**: 202. 1828.

The type species of the genus is *Gautieria morchelliformis* Vittadini.

Fructifications globose to somewhat irregular, with a simple or branched rhizomorph; columella variable in size and shape; peridium thin, fugacious; gleba white at first, becoming colored by the masses of spores; cavities variable in size, often elongated, labyrinthiform; septa homogeneous, composed of closely interwoven, parallel hyphae, not conspicuously gelatinized at maturity; basidia clavate, usually 2-spored, with long filiform sterigmata; spores ellipsoidal to citriform, unicellular, with longitudinal thickenings of the cell wall.

Although *Gautieria* was originally described as lacking a peridium, it has been reported[2] to have one in its early stages of development. For this reason we are inclined to consider *Chamonixia* Rolland as synonymous with *Gautieria,* but since

[1] Issued May 24, 1918.

[2] Corda, A. C. J. Icones Fungorum **6**: 33. 1854; Hesse, R. Die Hypogaeen Deutschlands **1**: see p. 106. 1891; Fitzpatrick, H. M. A comparative study of the development of the fruit-body in Phallogaster, Hysterangium, and Gautieria. Ann. Myc. **11**: 119–149. *pl. 4–7. f. 1–4.* 1913.

we have not studied the type material, we prefer not to change the name.

Although we have had the opportunity to study a few specimens which were put up in alcohol, our descriptions are based on dry herbarium specimens, as is also our key. As a standard for color descriptions we have used Ridgway, 'Color Standards and Nomenclature,' Washington, D. C., 1912. As to the citation of specimens, the data given is that received with the specimens. The location of all specimens is designated by giving in parenthesis the name of the herbarium preceded by "in."

We are indebted to the Missouri Botanical Garden for the use of the library and herbarium; to Dr. E. A. Burt for helpful suggestions; to Dr. LeRoy Abrams for the privilege of studying Harkness's type; to Mr. S. H. Burnham for his collections; to Dr. H. M. Fitzpatrick for specimens from New York; to Dr. N. L. Gardner for his collections; to Mr. C. G. Lloyd for the privileges of his herbarium; to Dr. W. A. Murrill for collections from the New York Botanical Garden Herbarium; to Mrs. F. W. Patterson for specimens from the Pathological Collections, Bureau of Plant Industry, United States Department of Agriculture; and to Dr. J. R. Weir for specimens from Idaho.

Key to the North American Species

1. Spores mostly more than 14 μ long 2
1. Spores mostly shorter than 14 μ 4
   2. Superficial cavities large and prominent ..... *G. morchelliformis* (p. 134)
   2. Superficial cavities small 3
3. Septa wholly composed of slender hyphae ..... *G. graveolens* (p. 136)
3. Septa composed of a pseudo-parenchyma; the subhymenium of large, angular cells ..... *G. Trabuti* (p. 137)
   4. Slate-colored to nearly black; columella long; cystidia present ..... *G. plumbea* (p. 138)
   4. Brownish; columella short; cystidia absent ..... *G. monticola* (p. 139)

1. **Gautieria morchelliformis**[1] Vittadini, Monogr. Tuberac. 26. 1831; Klotzsch in Dietr. Fl. Boruss. (Fl. Königr. Preuss.) **7**: No. 764. 1839, in part; Tulasne, Fung. Hypog. 62. 1851; Corda, Icon. Fung. **6**: 34. 1854; Winter in Rabenh. Krypt.-Fl.

[1] Originally spelled *morchellaeformis*.

Deutschl. ed. 2, **1**: 873. 1884; DeToni in Sacc. Syll. Fung. **7**: 177–178. 1888; Hesse, Hypog. Deutschl. **1**: 109–110. 1891.

Gautieria morillaeformis Quelet, Ench. Fung. 250. 1886.—*Gautieria villosa* Quelet, Soc. Bot. Fr. Bull. **25**: 290. 1878 (often cited as Champ. du Jura et des Vosges, Suppl. **6**: 290. 1878); Ench. Fung. 250. 1886; Winter in Rabenh. Krypt.-Fl. Deutschl. ed. 2, **1**: 873. 1884; DeToni in Sacc. Syll. Fung. **7**: 178. 1888.

Illustrations: Bucholtz, Ann. Myc. **1**: *pl. 5. f. 14;* Corda, Icon. Fung. **6**: *pl. 7. f. 62;* Bail in Nees v. Esenbeck, Th. F. L. & Henry, A. Syst. d. Pilze **2**: *pl. 27. f. 1–4;* Vittadini, Monogr. Tuberac. *pl. 3. f. 6;* Klotzsch in Dietr. Fl. Boruss. (Fl. Königr. Preuss.) **7**: *pl. 764.*

Type: location unknown to us.

Fructifications globose to oblong, 1–3 cm. in diameter, with a basal stalk-like rhizomorph, usually much branched; columella rudimentary, merely a subglobose summit of the rhizomorph; peridium thin in early stages, quickly evanescent; gleba ochraceous-tawny to hazel; cavities 1–6 mm. in diameter, subglobose to irregular; septa white when broken, hyaline to cream-colored under the microscope, composed of a stupose mat of hyphae, about 75 μ broad; basidia about as large as the spores, hyaline, granular, 2–3-spored; sterigmata filiform, as long as the spores; cystidia in the upper cavities of the fructification, not prominent; paraphyses clavate, septate, hyaline; spores fusiform to citriform, ochraceous, longitudinally striate, with 8–10 usually smooth striations, 1–2-guttulate, pedicellate, 12–24×8–12.5 μ.

In clay soil. Europe and United States. Spring and summer.

We have placed *Gautieria villosa* Quelet in synonymy, for we have been unable to distinguish it from *G. morchelliformis,* and Quelet himself later (1886) believed them to be the same species. Winter studied the type, as well as Bresadola's collection, which we have studied, and he believes they are synonymous. The villous character to which Quelet had reference might have been the granular appearance often produced by an accumulation of spores on the surface of the gleba.

Specimens examined:

Exsiccati: Roumeguère, Fung. Gall. Exsicc., 2218, under the name *G. villosa.*

Austria: Bohemia, Tabor, *F. Bubak* (in Lloyd Mus., 05860); Tyrol, near Magras, *G. Bresadola,* in Roumeguère, Fung. Gall. Exsicc., 2218 (in N. Y. Bot. Gard. Herb.).

France: Jura, *N. Patouillard* (in Lloyd Mus., 08+53).

New York: Washington Co., Hudson Falls, *S. H. Burnham* (in Burnham Herb., Dodge Herb., 850, and Zeller Herb., 1449).

California: Claremont, *L. M. Clency* (in Pomona Coll. Herb., 1759, and in Lloyd Mus., 1759); San Jose, *H. E. Parks* (Univ. Cal. Herb., 541, Zeller Herb., 1457, and Dodge Herb., 860).

2. Gautieria graveolens Vittadini, Monogr. Tuberac. 27. 1831; Tulasne, Fung. Hypog. 63. 1851; Corda, Icon. Fung. **6**: 34. 1854; Winter in Rabenh. Krypt.-Fl. Deutschl. ed. 2. **1**: 873–874. 1884; DeToni in Sacc. Syll. Fung. **7**: 178. 1888; Quelet, Ench. Fung. 250. 1886; Hesse, Hypog. Deutschl. **1**: 106–108. 1891.

Gautieria graveolens? Chatin, La Truffe, 82–83. 1892.—*Gautieria graveolens* var. *mexicana* Fischer in Engler & Prantl, Die Nat. Pflanzenfam. **I.** 1**: 305. 1899.

Illustrations: Bucholtz, Ann. Myc. **1**: *pl. 5. f. 14;* Chatin, La Truffe, *pl. 15. f. 4;* Corda, Icon. Fung. **6**: *pl. 7. f. 63;* Fischer in Engler & Prantl, Die Nat. Pflanzenfam. **I.** 1**: 304; Fitzpatrick, Ann. Myc. **11**: *pl. 4. f. 11, pl. 7. f. 30–37;* Hesse, Hypog. Deutschl. **1**: *pl. 2. f. 5–9, pl. 7. f. 4–6;* Vittadini, Monogr. Tuberac. *pl. 4. f. 3.*

Type: in Saccardo Herb. at Padua.

Fructifications globose, 1–2 cm. in diameter, light ochraceous-buff to Prout's brown; stipe slender and fragile, up to 1 cm. long, 1 mm. thick; columella frequently reaching the center of the fructification, forking; odor very strong, suggestive of decaying onions; peridium thin, composed of delicate, thin-walled, loosely woven hyphae, soon rupturing and disappearing; gleba ochraceous-tawny to cinnamon-brown; cavities globose or elongated, minute, empty; septa 40–80 μ

thick, composed of small hyphae, compact; cystidia clavate to subfusiform, hyaline, often obscured by the spores; paraphyses linear, septate; basidia broadly clavate, 2-spored, 12–16×8–9 μ, with long filiform sterigmata; spores ochraceous-tawny, usually with 10 prominent striations, the latter smooth or nearly so, apex rounded, base pedicellate, 18–19× 11–12 μ, often with a large oil globule.

Deeply buried under leaf mould. Europe and North America. Summer.

Specimens examined:

Exsiccati: Saccardo, D. Mycoth. Ital., 427; de Thümen, Mycoth. Univ., 12.

Austria: Bohemia, Vysoky, Chluniec ad Selcany, *F. Bubak* (in Lloyd Mus., 058590); Tyrol, Cavelonte, *G. Bresadola,* in D. Saccardo, Mycoth. Ital., 427 (in U. S. Dept. Agr., Bur. Pl. Ind. Path. Coll.).

Germany: Saxony, Eisleben, *J. Kunze* (collections in Lloyd Mus., 05916, and in Mo. Bot. Gard. Herb., 5637); *G. Winter,* in de Thümen, Mycoth. Univ., 12 (in Lloyd Mus., Mo. Bot. Gard. Herb., and U. S. Dept. Agr., Bur. Pl. Ind. Path. Coll.).

New York: Ithaca, *H. M. Fitzpatrick* (in N. Y. Coll. Agr. at Cornell Univ., Dept. Pl. Path. Herb., 8450).

3. Gautieria Trabuti (Chatin) Patouillard, Soc. Myc. Fr. Bull. **13**: 203–204. 1897.

Hymenogaster Trabuti Chatin, Soc. Bot. Fr. Bull. **38**: 64. 1891.

Illustrations: Patouillard, Soc. Myc. Fr. Bull. **13**: *pl. 13. f. 2.*

Type: probably in Patouillard Herb. but unknown to us.

Fructifications subglobose, about 3 cm. in diameter, surface convoluted, Verona brown in preserved material; stipe slightly developed, arising from very fine, brown rhizomorphs of septate hyphae with prominent clamp connections; columella dendroid; peridium made up of loosely woven, large, septate hyphae with swollen cells, soon evanescent; gleba Brussels-brown; cavities irregular, empty; septa hyaline, 180–240 μ thick, composed of a pseudo-parenchyma of

large, subglobose to polygonal cells; cystidia subcylindric, thin-walled, 8 μ in diameter; paraphyses filiform, septate, guttulate, 3–4 μ in diameter; basidia hyaline, many-guttulate, 25–30×10–16 μ, obovate to clavate, mostly 4-spored; sterigmata stout, 5–8 μ long; spores acrogenous, 1–3-guttulate, cinnamon to cinnamon-buff, short-pedicellate, globose when young, becoming ellipsoidal, 16–21×8–10 μ, with 5–9 striations usually prominently warted.

Deeply buried in forests. Algeria and California. April.

Specimens examined:

California: San Jose, *H. E. Parks* (in Univ. Cal. Herb., 493, Zeller Herb., 1455, and Dodge Herb., 858).

4. Gautieria plumbea Zeller & Dodge, sp. nov.

Fructificationes ovatae, 4 cm. diametro metiens, cordis effigies, superficie convoluta, "light brownish olive" vel "mummy-brown" (Ridgway); stipes 2 mm. crassitudine; columella ramosa, fere fructificationem percurrens, translucens; gleba "plumbeous-black" vel "slaty" (Ridgway) servata, "fuscous-black" (Ridgway) siccata, gelatinosa; locelli irregulares, vacui; septa hyalina, circa 300 μ crassitudine, hyphis gelatinosis confecta; stratum subhymeniale pseudo-parenchymate, id est, cellulis polygoniis confectum; cystidia magna, 52–61×25–35 μ, hyalina, granulate guttulata, obovata, saepe subapiculata; paraphyses anguste clavatae, granulate guttulatae, septatae, 4–5 μ crassitudine, partim apice bullatae, partim filiformes; basidia hyalina, granulate guttulata, clavata, 20–26×9–10 μ, mono- vel tetraspora, sterigmatibus brevibus; sporae 11–16×6.5–8 μ, breviter pedicellatae, longitudinaliter striatae, striis 7–10, sinuosis, "English red" vel "burnt sienna" (Ridgway); sporae iuniores ovatae vel ellipsoideae, breviter pedicellatae, leves, deinde striatae.

Habitat in terra in pinetis. Idaho. Autumno.

Type: in Weir Herb., Zeller Herb., and Dodge Herb.

Fructifications ovate, 4 cm. in diameter, heart-shaped, surface convoluted, light brownish olive to mummy-brown; stipe 2 mm. thick; columella branched, trunk reaching almost to the top of the fructification, translucent; gleba plumbeous-black, slaty when in preservative, drying fuscous-black, gelatinous; cavities irregular, empty; septa hyaline, about 300 μ thick, composed of gelatinized hyphae; subhymenial layer a pseudo-parenchyma of large angular cells; cystidia large, 52–61×25–35 μ, hyaline, granularly guttulate, obovate, often somewhat apiculate; paraphyses narrowly clavate, hyaline,

granularly guttulate, septate, 4–5 μ broad, some knobbed at the tip, some filiform; basidia hyaline, granularly guttulate, clavate, 20–26×9–10 μ, 1–4-spored; sterigmata less than half the length of the spores; spores 11–16×6.5–8 μ, short-pedicellate, longitudinally striate, with 7–10 wavy striations, from English red to burnt sienna; young spores ovate to ellipsoidal, short-pedicellate, smooth, then striate.

Under conifers. Idaho. September to October.

The color of the gleba and the prominence of the columella make this species distinct from all others. It is most closely allied with *G. Trabuti* in tramal characters, but the spores are more nearly the size of *G. monticola* than those of any other species.

Specimens examined:

Idaho: Priest River, *J. R. Weir,* type (in Weir Herb., in Zeller Herb., 1458, and Dodge Herb., 859).

5. Gautieria monticola Harkness, Cal. Acad. Sci. Bull. **1**: 30. 1884; DeToni in Sacc. Syll. Fung. **7**: 178–179. 1888.

Hymenogaster monticolus Harkness, Cal. Acad. Sci. Proc. Bot. III. **1**: 249. 1899.

Type: in Dudley Herb. at Leland Stanford Jr. Univ. and in N. Y. Bot. Gard. Herb.

Fructifications irregularly lobed, nearly plane above and below, 10 cm. in diameter (Harkness), about 3 cm. thick, Dresden brown to mummy-brown; stipe short, slender, darker; columella short, branching, concolorous with the stipe; peridium evanescent; gleba ochraceous-tawny, grayish where cut, due to the thick, hyaline septa; cavities irregular, more or less anastomosing, nearly filled with spores when dry; septa 140–400 μ thick, hyaline, composed of more or less gelatinized hyphae, mostly parallel with the hymenial surface; cystidia none; basidia arising from erect, septate hyphae, hyaline, 16×6–7 μ, ovate, mostly 2-spored; sterigmata filiform, 7–10 μ long; spores acrogenous, 1–several-guttulate, ochraceous-tawny, short-pedicellate, ellipsoidal to obovate, 9–13×6.5–8 μ, with 7–10 longitudinal or oblique striations sometimes slightly warted.

On the ground under conifers. California. July.

Specimens examined:

California: Mariposa County, Big Meadow, *W. A. Setchell* (in Univ. Cal. Herb., 542, Zeller Herb., 1454, and Dodge Herb., 857); Big Tree Grove, *H. W. Harkness, 113* [*3543*], type (in Dudley Herb. at Leland Stanford Jr. Univ. and N. Y. Bot. Gard. Herb.).

EXTRA-LIMITAL AND DOUBTFUL SPECIES

The following are descriptions of species not yet found in North America, but are included in order to assist in referring material to them in case they should be discovered later, as individual species are found to have a wide range. The descriptions are either copies or translations of the original descriptions, since no material here has been studied. Such notes are appended to them as seemed justified by a careful study of the original text and illustrations.

1. **Chamonixia caespitosa** Rolland, Soc. Myc. Fr. Bull. **15**: 76. 1899; Saccardo and Sydow in Sacc. Syll. Fung. **16**: 251. 1902.

Illustrations: Rolland, Soc. Myc. Fr. Bull. **15**: *pl. 6. f. 3.*

Type: location unknown to us.

Globose mass of several fructifications, pressed against each other like the carpels of an orange but easily separable, covered by a membranous peridium, floccose-silky, white, bluing rapidly to the touch. The peridium surrounds the outside of the fructification but not where the several fructifications come together. Gleba fleshy, flesh-colored, of round or oval cavities, no sterile portions; basidia 2-spored; spores brown, ellipsoidal, longitudinally striate, 20×12 μ, guttulate. Floccose, radicating mycelium below, odorless. In cross-section the peridium shows distinctly, being blue where cut.

Among mosses clothing the base of an old tree (*Abies excelsa*), Bois du Bouchet near Chamonix, Sept. 15, 1898.

—Rolland.

This species seems to be a *Gautieria,* although we prefer not to make the transfer until we have seen the type. It seems quite possible that the columella is more strongly developed in this species, running all the way through the fructification and dividing the gleba into several distinct portions, as there is a tendency to do in *G. plumbea.* The spore color seems to relate it to the latter species if the colors of the illustration are to be trusted.

2. Gautieria Otthii Trog, Naturforsch. Ges. Bern Mitt. **1857**: 43. 1857 (in Nos. 388–390) [sometimes cited as Verzeichniss schweiz. Schwämme Nachtrag **3**: 43. 1857]; Saccardo & Sydow in Sacc. Syll. Fung. **14**: 268. 1899.

Fructification globose, 1–1¼ inch long, slightly narrower, with a "rootlet" at the base connected with a white columella. The long, somewhat winding cavities are numerous and small, visible with a weak lens, within larger but uniformly distributed, and as there is no peridium, the cavities are visible on the upper surface, of the same form as those within. They are wholly formed by the hymenium which bears striped, egg-shaped spores on short basidia. Spores brown and filled with granules. Odor weak, unpleasant.

Hardlisberg, Switzerland. *Otth.*

—Trog.

There seems to be nothing in the above description to differentiate *G. Otthii* from *G. graveolens* Vitt. As both common species of *Gautieria* have been reported from Switzerland and as Trog reports *G. morchelliformis* Vitt., it seems highly probable that this species should be reduced to synonymy, but it seems unwise to do so before studying type material or material from the type locality.

3. Gautieria Drummondi Cooke, Handbook of Australian Fungi, 247. 1892.

Illustration: Cooke, Handbook of Australian Fungi, *pl. 15. f. 130.*

"Subglobose, small; cells sinuous; spores ellipsoid, with large nucleus, 14–15×8 μ, hyaline.

"In the soil. W. Australia."

—Cooke.

Cooke described this form from a specimen (No. 4446 in Berkeley's herbarium) in fragmentary condition. If Cooke's drawings are at all reliable, this plant is a *Rhizopogon* and would probably fall into synonymy in that genus. The spore measurements are rather larger than in many species of *Rhizopogon,* but much smaller than any in *Gautieria* except *G. monticola* and *G. plumbea.* Only a study of the type material can decide the position of this species. The description would fit either genus.

EXPLANATION OF PLATE

PLATE 9

Fig. 1. Spores of *Gautieria morchelliformis;* ×1000.

Fig. 2. Spores of *G. graveolens;* ×1000.

Fig. 3a. Showing the forms of hyphae in the evanescent peridium of *G. Trabuti;* ×625.

Fig. 3b. The guttulate paraphyses of *G. Trabuti;* ×1000.

Fig. 3c. A cystidium of *G. Trabuti;* ×1000.

Fig. 3d. Showing basidia and spores of *G. Trabuti,* the ribs of the spores being usually warted; ×1000.

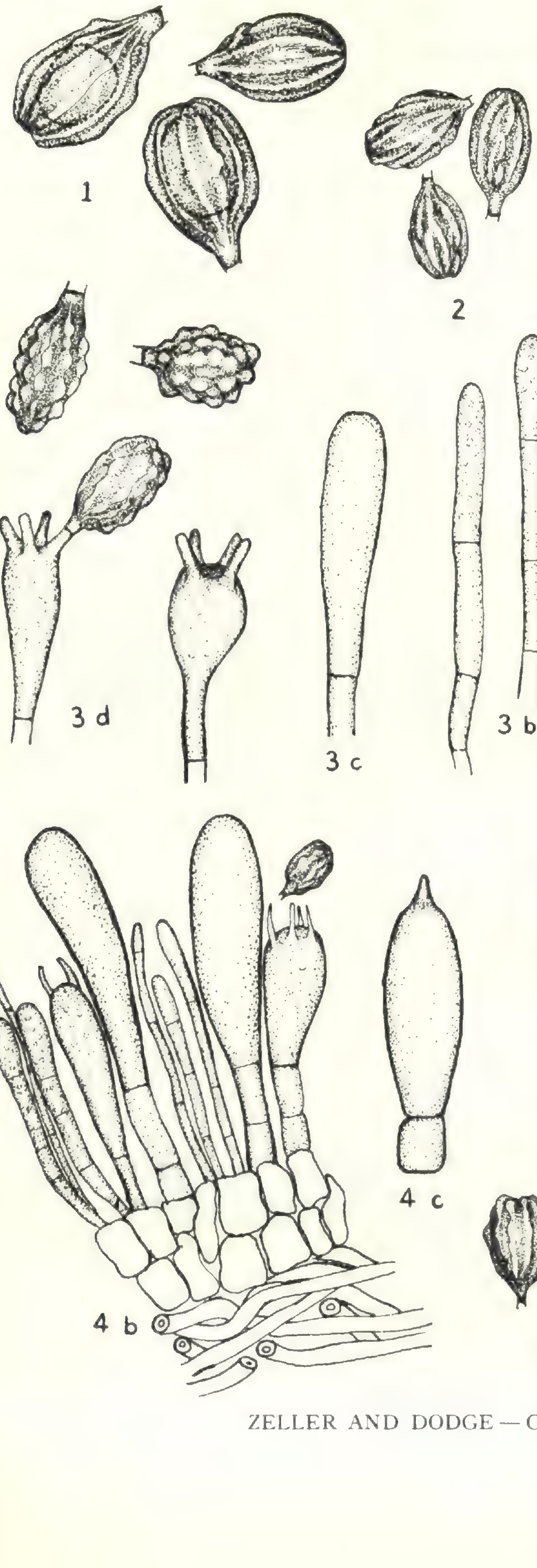
Fig. 4a. A vertical median section of a fructification of *G. plumbea,* showing the stalk, branching columella and gleba; nat. size.

Fig. 4b. Section of the hymenium of *G. plumbea,* showing gelatinized tramal hyphae, angular cells of the subhymenium, paraphyses, cystidia, and basidia; ×625.

Fig. 4c. Showing a cystidium with apiculate tip; ×625.

Fig. 4d. Spores of *G. plumbea;* ×1000.

Fig. 5. Spores of *G. monticola;* ×1000.



ZELLER AND DODGE — GAUTIERIA

NOTES ON CERTAIN CRUCIFERAE

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Synthlipsis Gray

Pods oblong, strongly flattened contrary to the septum; valves sharply carinate, distinctly margined at the apex; areolae of septum not at all tortuous; ovules 6–12 in each cell; seeds with a mucilaginous testa whose cells emit spiral threads when wet.

S. Greggii Gray, Mem. Am. Acad. N. S. [Pl. Fendl.] **4**: 116. 1849.

Synthlipsis, as originally limited, remains monotypic and quite distinct from *Lesquerella* by reason of the carinate valves, the different septum, and the mucilaginous seed coat. Several other species have from time to time been referred to this genus because of their flattened pods. In all other ways, however, these agree with *Lesquerella* and in that genus they must be placed. One species seems even to have been described and maintained under two names—*S. Berlandieri* Gray and *Lesquerella lasiocarpa* (Hook.) Wats.

Physaria Gray

A complete revision of this genus is in course of preparation, but until such time as that may be completed it was thought the following synopsis would be useful in the determination of exsiccatae.

Key to the Species and Varieties

A. Mature pods globose-inflated, not strongly flattened laterally.
  a. Shoulders of upper sinus (of pods) rounded.
    a. All the stems lateral; pods usually erect.
      I. Basal leaves obtuse; blade usually circular in outline.
        1. Pods cordate at base.
          * Basal leaves appressed-stellate.
            † Pubescence of young pods spreading; basal leaves angularly toothed.... *1. P. didymocarpa*
            †† Pubescence of young pods appressed; basal leaves entire or undulately toothed ..... *1a.* var. *australis*
          ** Basal leaves conspicuously lanate..... *1b.* var. *lanate*

2. Pods acute, obtuse or truncate at the base but scarcely cordate.
   * Basal leaves fiddle-shaped; plants of Colorado ..... *2. P. vitulifera*
   ** Basal leaves mostly entire; coarse plants of western Nebraska and the Dakotas ..... *3. P. brassicoides*

II. Basal leaves acute; blade lanceolate in outline.
1. Basal leaves mostly entire..... *4. P. acutifolia*
2. Basal leaves more or less pinnatifid..... *5. P. floribunda*

β. Terminal sterile soboles developing from the rosette; pods pendent..... *6. P. Osterhoutii*

b. Shoulders of the upper sinus angular, in young pods at least; pods furnished with keels along which the walls fold on drying..... *7. P. Newberryi*

B. Mature pods strongly flattened laterally.
a. Pods obcordate in outline; replum about 5 mm. long..*8. P. Geyeri*
b. Pods obreniform or broadly elliptical in outline; replum much longer.
a. Style 1–2 mm. long; base of pods obtuse or truncate ..... *9. P. oregona*
β. Style about 5 mm. long; base of pods cordate....*10. P. alpestris*

1. P. didymocarpa (Hook.) Gray in Wats. Bot. King's Exp. 20. 1871.

This species in its typical form is predominantly northern, occurring in the mountains from southern Canada to Wyoming and northern Utah.

1a. Var. **australis,** n. var.[1]

Basal leaves entire or undulately toothed; pubescence of leaves and young pods closely appressed.

Distribution: this variety replaces the typical form in southern Wyoming, Colorado, northern New Mexico, and in parts of Utah.

Specimens examined:

Wyoming: Sand Creek, Albany Co., June 1, 1900, *A. Nelson 7026* (Mo. Bot. Gard. Herb. and Rky. Mt. Herb.); dry white hills, Dyer's Ranch, Carbon Co., June 21, 1901, *Goodding 80* (Mo. Bot. Gard. Herb. and Rky. Mt. Herb.); Cokeville, June 11, 1898, *A. Nelson 4637* (Rky. Mt. Herb.); Ft. Bridger, June 9, 1898, *A. Nelson 4602* (Rky. Mt. Herb.); Granger, June 13, 1898, *A. Nelson 4688* (Rky. Mt. Herb.); Green River, May 30, 1897, *A. Nelson 3032* (Rky. Mt. Herb.);

[1] **Physaria didymocarpa** (Hook.) Gray, var. **australis,** var. nov., foliis radicalibus integris vel sinuato-dentatis; siliquis junioribus adpresse pubescentibus. —Collected on gravel washes, Placerville, Colorado, July 23, 1917, *Payson 1093* (Mo. Bot. Gard. Herb.), TYPE.

Ft. Steele, June 18, 1898, *A. Nelson 4834* (Rky. Mt. Herb.); Green River, July 9, 1897, *Williams* (Rky. Mt. Herb.); Bates Creek, July 5, 1901, *Goodding* (Rky. Mt. Herb.).

Colorado: dry hills, Naturita, April 22, 1914, *Payson 247* (Mo. Bot. Gard. Herb. and Rky. Mt. Herb.); foothills near Mancos, June 23, 1898, *Baker, Earle & Tracy 75* (Mo. Bot. Gard. Herb. and Rky. Mt. Herb.); Mack, May 27, 1908, *Jones* (Mo. Bot. Gard. Herb.); gravel washes, Placerville, July 23, 1917, *Payson 1093* (Mo. Bot. Gard. Herb. and Rky. Mt. Herb.), TYPE; dry, rocky slopes, Paradox, June 13, 1912, *Walker 89* (Rky. Mt. Herb.); Mesa Verde National Park, 1913, *Haas 40* (Rky. Mt. Herb.); hills near Montrose, May 3, 1913, *Payson 75* (Rky. Mt. Herb.).

New Mexico: Aztec, April, 1899, *Baker 356* (Rky. Mt. Herb.).

Utah: gravel, Cedar City, May 8, 1894, *Jones 5202* (Mo. Bot. Gard. Herb.); near Fish Lake, May 17, 1875, *Ward 48* (Mo. Bot. Gard. Herb.); east slope, Steptoe Valley, May 13, 1859, *H. Engelmann* (Mo. Bot. Gard. Herb.); Echo, May 7, 1890, *Jones* (Mo. Bot. Gard. Herb.); Mt. Nebo, Aug. 15, 1905, *Rydberg & Carlton 7740* (Rky. Mt. Herb.); shale slopes, Brush Creek Canyon, Uintah Mts., July 17, 1902, *Goodding 1279* (Rky. Mt. Herb.).

1b. Var. **lanata** A. Nels. Bull. Torr. Bot. Club **31**: 241. 1904.

P. lanata Rydb. Bull. Torr. Bot. Club **39**: 322. 1912.

Distribution: northern Wyoming and Montana.

2. P. vitulifera Rydb. Bull. Torr. Bot. Club **28**: 278. 1901.

P. didymocarpa Gray, Am. Jour. Sci. & Arts II. **33**: 243. 1862.

Distribution: in the mountains of Colorado.

3. P. brassicoides Rydb. Bull. Torr. Bot. Club **29**: 237. 1902.

Distribution: western Nebraska to southwestern North Dakota.

4. P. acutifolia Rydb. Bull. Torr. Bot. Club **28**: 279. 1901.

Distribution: in the mountains of Colorado.

5. P. floribunda Rydb. Bull. Torr. Bot. Club **28**: 279. 1901.
Distribution: in the mountains of Colorado.

6. P. Osterhoutii, n. sp.[1]

Silvery stellate perennial from a simple or branched caudex; basal leaves small, blade lanceolate to hastate, usually acute, 5–10 mm. long, petiole 5–15 mm. long; cauline leaves from narrowly hastate or lanceolate to linear, 1–3.5 cm. long; caudex branches terminated by sterile, leafy soboles 1–4 cm. long; flowering stems lateral, decumbent-ascending, leafy, 8–12 cm. long; flowers yellow, conspicuous, fruiting inflorescence elongating; pedicels recurved, 1 cm. or more long; pods pendent, obcordate, base truncate or obtuse, apex deeply emarginate, cells inflated, rather loosely stellate; styles slender, about 4 mm. long, stigma capitate.

Distribution: north central Colorado.

Specimen examined:

Colorado: Kremmling, Grand Co., June 22, 1907, *Osterhout 3477* (Rky. Mt. Herb.), TYPE.

Named in honor of Mr. Geo. E. Osterhout, of Windsor, Colorado, who was the first to recognize its specific distinction from the other known species of *Physaria.*

7. P. Newberryi Gray, Ives' Rept. Colo. River, pt. 4, 6. 1861.

P. didymocarpa (Hook.) Gray, var. *Newberryi* Jones, Proc. Calif. Acad. Sci. II. **5**: 624. 1895.

Distribution: northeastern New Mexico, southern Utah, northern Arizona, and southern Nevada.

8. P. Geyeri (Hook.) Gray, Gen. Illustr. **1**: 162. 1848.
Distribution: eastern Washington to western Montana.

9. P. oregona Wats., Proc. Am. Acad. **17**: 363. 1882.

[1] **Physaria Osterhoutii,** sp. nov., planta perennis undique indumento argenteo-stellata; caudicis ramis adscendentibus in soboles foliosas steriles terminantibus; foliis radicalibus petiolatis (petiolis 5–15 mm. longis) plus minusve hastatis, laminis lanceolatis plerumque acutis; foliis caulinis similibus sed angustioribus 1–3.5 cm. longis; caulibus foliosissimis 8–12 cm. longis; corolla flava; racemis remotifloris post anthesin; pedicellis fructiferis recurvatis circa 1 cm. longis; siliquis obcordatis basi truncatis vel obtusis, apice valde emarginatis laxe stellato-pubescentibus; stylo circa 4 mm. longo.—Collected at Kremmling, Grand Co., Colorado, June 22, 1907, *Osterhout 3477* (Rky. Mt. Herb.), TYPE.

Distribution: eastern Oregon.

10. **P. alpestris** Suksdorf, West Am. Scientist **15**: 58. 1906.
Distribution: south central Washington.

Dithyrea Harv.

This North American genus differs from the Mediterranean genus *Biscutella* in three conspicuous ways. *Dithyrea* has branched hairs, a stigma, the lobes of which extend over the middle of the carpels, and a replum of two distinct limbs which subtend a narrow, though evident, septum. *Biscutella,* on the other hand, exhibits unbranched hairs, a stigma, the lobes of which extend over the placentae, and a replum with fused limbs and obsolete septum. Although the two genera seem amply distinct, it appears impossible to accept Prantl's view that they belong in different sections of the family.

Key to Species and Varieties

A. Calyx spreading; pubescence of pods branched or stellate.
  a. Leaves thick, lanceolate to linear, densely pubescent.
    α. Leaves narrowly lanceolate to linear; stems branching, not strict.....*1a.* var. *Griffithsii*
    β. Leaves broadly lanceolate; stems inclined to be strict.
      I. Leaves cuneate at the base.....*1. D. Wislizenii*
      II. Leaves truncate at the base; stems strict....*1b.* var. *Palmeri*
  b. Leaves thin, ovate or oblong, sparingly pubescent..*2. D. membranacea*

B. Calyx tubular; pubescence of pods of flattened unbranched cilia.
  a. Style about 0.5 mm. long; mature pods 6–8 mm. broad.
    α. Corolla dull white; inland plants.....*3. D. californica*
    β. Corolla purplish; beach plants.....*3a.* var. *maritima*
  b. Style nearly or quite 1 mm. long; mature pods 3–4 mm. broad .....*4. D. clinata*

1. **D. Wislizenii** Engelm. Wisliz. Tour N. Mexico, 95. 1848.
Distribution: western Texas, southern New Mexico, and adjacent Mexico.

D. Wislizenii in the aggregate exhibits within its large range three fairly distinct but more or less arbitrarily limited phases. Fortunately enough, the type was collected from near the geographical center of distribution and represents a form intermediate between the two varieties. The species in its typical form passes gradually on the east into the variety *Palmeri* and on the north and west into the

variety *Griffithsii*. Probably it is only in southern New Mexico and territory adjacent that the three phases are found together. Forms with glabrous pods occur occasionally throughout the species, and this character is in no way a specific one.

1a. Var. **Griffithsii** (Wooton & Standley), n. comb.

D. Griffithsii Wooton & Standley, Contr. U. S. Nat. Herb. **16**: 124. 1913.

Distribution: western Texas, New Mexico, Arizona, southern Utah, and southern Nevada.

1b. Var. **Palmeri**, n. var.[1]

Pubescence very dense, almost velvety; stems about 5 dm. high, stout, branched upwards, branches strict, erect, leafy; cauline leaves thick, sessile or nearly so, ascending, lanceolate, 2–3.5 cm. long, entire or shallowly toothed, margins undulate.

Distribution: from southwestern Oklahoma, through northwestern Texas to southern New Mexico.

Specimens examined:

Oklahoma: Cimarron River, July 12, 1899, *White 155* (Mo. Bot. Gard. Herb.); sand by creek, near Granite, Greer Co., June 17, 1913, *Stevens 1036* (Mo. Bot. Gard. Herb.); Greer Co., July 18, 1901, *White* (Rky. Mt. Herb.); Red River Valley, July 12, 1903, *Duncan 79* (Mo. Bot. Gard. Herb.); Woodward Co., June 28, 1900, *White* (Rky. Mt. Herb.).

Texas: saline sands, Estelline, June 1, 1902, *Reverchon 2971* (Mo. Bot. Gard. Herb.); sandy ground near Colorado, June 9, 1900, *Eggert* (Mo. Bot. Gard. Herb.); salty sands, Colorado City, April, 1882, *Reverchon* (Mo. Bot. Gard. Herb.); sandy open ground, Big Spring, Howard Co., July 9, 1917, *Palmer 12493* (Mo. Bot. Gard. Herb.), TYPE.

New Mexico: Arroyo Ranch, near Roswell, May, 1903, *Griffiths 4266* (Mo. Bot. Gard. Herb.).

[1] **Dithyrea Wislizenii** Engelm., var. **Palmeri**, var. nov., robusta plerumque stricta circa 5 dm. alta superne ramosa, pube ramosa brevi velutina; ramis foliosissimis strictis; foliis caulinis sessilibus vel fere sessilibus non patentibus lanceolatis basi truncatis 2–3.5 cm. longis.—Collected on sandy open ground, Big Spring, Howard Co., Texas, July 9, 1917, *Palmer 12493* (Mo. Bot. Gard. Herb.), TYPE.

This variety is named in honor of Mr. E. J. Palmer, from whose excellent Texan collections the type has been chosen.

2. D. membranacea, n. sp.[1]

Annual or biennial, green, rather sparsely pubescent with loose imperfect stellae or branching hairs; stems several from the root, sparingly branched, slender, decumbent, 3–6 dm. long; cauline leaves thin, narrowed abruptly at the base into a slender petiole about 1 cm. long, blade 3–4 cm. long, 2.5–3 cm. broad, irregularly ovate or oblong in outline, toothed or undulately lobed, apex broad and rounded; basal leaves unknown; sepals spreading, purplish; petals white, orbicular to oblong, abruptly narrowed to a very short claw and then somewhat dilated to point of insertion, margin irregular; filaments scarcely broadened at base; fruiting inflorescence elongated, pedicels about 12 mm. long, slender, divergent; pods apparently yet immature, erect or ascending, pubescent with two quite distinct sizes of branched hairs, substipitate, reticulated, and apparently lacking the margin so conspicuous in *D. Wislizenii,* cells nearly orbicular, about 4 mm. in diameter, replum about as long; style scarcely 1 mm. long, stigma subcapitate, slightly elongated over the middle of the carpels.

Distribution: Tamaulipas, Mexico.

Specimen examined:

Mexico: vicinity of Victoria, Tamaulipas, alt. about 320 m., February 1–April 9, 1907, *Dr. Edward Palmer 87* (Mo. Bot. Gard. Herb.), TYPE.

It is extremely interesting to find another species of *Dithyrea* very different from either of the two previously known. In general aspect it is much more like *D. californica* than *D. Wislizenii,* but in the characters of the flowers and fruit it is surely nearer the latter. The specific name was sug-

[1] **Dithyrea membranacea,** sp. nov., *D. Wislizenii* peraffinis sed caulibus foliisque viridibus parce pubescentibus; caulibus gracilibus decumbentibus 3–6 dm. longis; foliis caulinis membranaceis subovatis vel oblongo-ovatis circa 3–4 cm. longis 2.5–3 cm. latis plus minusve undulato-dentatis basi in petiolum circa 1 cm. longum abrupte attenuatis apice rotundatis; calycis lobis patentibus purpureo-tinctis; corolla alba; siliquiis reticulatis non (?) marginatis.—Collected in the vicinity of Victoria, Tamaulipas, February 1–April 9, 1907, *Palmer* 87 (Mo. Bot. Gard. Herb.), TYPE.

gested by the thin leaves which are in such striking contrast to those of the other species.

3. D. californica Harv. in Hook. Lond. Jour. Bot. 4: 77, *pl. 5*. 1845.

Distribution: southern Nevada, western Arizona, southern California, and northern Lower California.

3a. Var. **maritima** Davidson in Gray, Syn. Fl. N. Am. **1**[1]: 123. 1895.

Distribution: "occasional along the seashore between Redondo and Port Ballona," southern California.

4. D. clinata Macbr. & Pays., n. sp.[1]

Slender-stemmed annual or biennial less than 3 dm. high; stems few, erect except at the subdecumbent base, simple or branched once toward the summit, sparsely pubescent; leaves subcinereous with branched hairs; basal leaves somewhat lyrately subpinnatifid, about 4 cm. long including the slender petiole, 5–10 mm. broad; stem-leaves few, gradually reduced upward, subentire or undulately lobed, ovate-oblong, the middle cauline, 1–1.5 cm. long, about 5 mm. broad, the uppermost about 5 mm. long and about 2.5 mm. broad; inflorescence about 1 dm. long; pedicels in fruit more or less recurved; petals white (?), scarcely 10 mm. long, exceeding the purplish sepals by about 2.5 mm.; style nearly 1 mm. long; fruit similar to that of *D. californica* but rarely half as large.

Distribution: unknown.

Specimen examined:

Lower California: Lagoon Head, March 6–15, 1889, *Dr. Edward Palmer 824* (Gray Herb.), TYPE.

Draba Standleyi Macbr. & Pays., nom. nov.

D. gilgiana Wooton & Standley, Contr. U. S. Nat. Herb. **16**:

[1] **Dithyrea clinata** Macbr. & Pays., spec. nov., planta annua vel biennis circa 3 dm. alta; caulibus gracilibus simplicibus parce pubescentibus; pilis ramosis; foliis cinereo-pubescentibus, radicalibus lyrato-subpinnatifidis circa 4 cm. longis 5–10 mm. latis basi in petiolum circa 1.5 cm. longum abrupte attenuatis, caulinis superioribus paucis gradatim reductis ovato-oblongis plus minusve sinuato-dentatis; racemis circa 1 dm. longis; pedicellis fructiferis plus minusve recurvatis; corolla ut videtur alba vix 10 mm. longa calycem superante 2.5 mm.; stylo fere 1 mm. longo; fructu ut apud *D. californicam* sed solum 3–4 mm. lato. —Collected at Lagoon Head, Lower California, March 6–15, 1889, *Palmer 824* (Gray Herb.), TYPE.

124. 1913, not *D. Gilgiana* Muschler in Fedde, Rep. Nov. Sp. **3** : 212. 1906.

The use by Muschler in 1906 of the name *Gilgiana* for a seemingly valid species of *Draba* in Asia Minor precludes the acceptance of this name for the distinctive, more recently published, New Mexican plant. Accordingly we have renamed the American species.

THE EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION

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Two earlier reports[1] from this laboratory seemed sufficiently to establish the point that a film of Bordeaux mixture increases the rate of transpiration of excised leaves of the castor bean, and likewise of potted tomato and potato plants. It was further indicated that other surface films, and to a slight extent dusts, may produce a similar, though on the whole lesser, accelerating effect. Nevertheless, it was felt that this work left incompletely answered questions relating both to the immediate and final effects of the spray, as well as to the relation of the acceleration found to night and day conditions, or to changes of environmental conditions in general. Again, it seemed eminently desirable to construct and employ in this work a rotating table, or transpirotaplane, by means of which it might be hoped to eliminate such errors as might arise from differing transpiration rates induced through the position of the plants in the different intervals, whether the plants observed were in the greenhouse or in the open. In the earlier experiments it had not been possible to take sufficient cognizance of these points, but immediately upon the presentation of the reports referred to above, further experiments were begun leading in the directions indicated. A variety of considerations prevented a prompt conclusion of this work. Meanwhile, there has appeared a paper by Martin[2] affording interesting and definite

[1] Duggar, B. M., and Cooley, J. S. The effect of surface films and dusts on the rate of transpiration. Ann. Mo. Bot. Gard. **1**: 1–22. *pl. 1.* 1914; The effects of surface films on the rate of transpiration: experiments with potted potatoes. *Ibid.* 351–356. *pl. 18.* 1914.

[2] Martin, W. H. Influence of Bordeaux mixture on the rates of transpiration from abscised leaves and from potted plants. Jour. Agr. Res. **7**: 529–548. 1916.

confirmation of the previous work, at the same time extending the findings of Duggar and Cooley regarding the accelerating effect of Bordeaux mixture and other surface films on the rate of transpiration of abscised leaves and potted plants. This work of Martin, conducted at the New Jersey Experiment Station, has been followed by a paper from Shive and Martin[1] on the effect of similar films upon the transpiring power of leaves, employing the method of standardized cobalt chloride paper as perfected through the work of Livingston and Shreve.[2] The method referred to has proved applicable to the investigation of problems of this nature, and affords further decisive evidence of the increased transpiring power of leaves sprayed with Bordeaux. Lutman,[3] in his careful study of Bordeaux mixture, has considered transpiration only in a subsidiary manner. He reviews the earlier work of the German observers, which, however, is based on rather inadequate experimentation, and seemed rather inclined to assume that increased transpiration might not be expected; yet his own experiments, so far as they go, indicate in general an increase in transpiration due to the Bordeaux film.

METHODS

In undertaking the present study it was decided to construct a rotating table, for the reasons given above, especially in an effort to eliminate the often rather serious error in transpiration studies, due to differences of exposure of the individual plants involved in the experiment. A rotating table was accordingly devised similar in principle to Livingston's[4] table for standardizing porous cup atmometers; in addition, however, to the revolution of the several plants about

[1] Shive, J. W., and Martin, W. H. The effect of surface films of Bordeaux mixture on the foliar transpiring power in tomato plants. Plant World **20** : 67–86. *f. 1.* 1917.

[2] Livingston, B. E., and Shreve, E. B. Improvements in the method for determining the transpiring power of plant surfaces by hygrometric paper. *Ibid.* **19** : 287–309. 1916.

[3] Lutman, B. F. Some studies on Bordeaux mixture. Vt. Agr. Exp. Sta., Bul. 196:1–80. *pl. 1–4. f. 1–11.* 1916.

[4] Livingston, B. E. A rotating table for standardizing porous cup atmometers. Plant World **15** : 157–162. *f. 1–2.* 1912.

the central axis, each plant was made to turn upon the axis of its own platform.

The construction of the table was as follows:

A heavy cast-iron base, 5 inches in diameter and 3½ inches high, with a footing 12 inches in diameter and 1½ inches thick, supported a polished steel shaft of 1-inch diameter, 4 feet long. Four inches of this shaft were sunk into the top of the base, which had a small shoulder. On this shoulder rested a collar or ring enclosing a set of ball bearings which was slipped over the shaft, these carrying the greater part of the weight of the revolving system.

The 8 arms carrying the plant platforms consisted of 1×1½-inch channel irons, 4 feet long, arranged radially and bolted each with 2 bolts to a central plate 10 inches in diameter. This central plate was screwed to a short collar or outer shaft of iron tubing of 3/16-inch thickness which slipped easily over the supporting steel central shaft without excessive play. On the portion of the collar below the central plate was bolted a sprocket wheel 8½ inches in diameter. The collar extended a little more than 1 inch above the central plate. Above this collar was imposed another short collar which was firmly screwed with set screws to the central steel shaft and did not bear upon any of the parts below; a sprocket wheel 3 inches in diameter was bolted to this second collar and a second ring of ball bearings fitted over the latter. On this ring then rested the second outer shaft, which revolved freely over the main steel axis, and extended a short distance above it.

The plant platforms consisted of discs of seasoned wood ¾ inch thick and 7 inches in diameter. To the bottom of each was screwed a brass sprocket wheel 2½ inches in diameter. Each of such sprockets fitted over a cylindrical steel plug ⅝ inch in diameter, projecting ⅞ inch above the top of a rectangular cast-iron sleeve which slid along the channel iron. The platform could thus be set at any point along the arm, and was fixed by a set screw in one side of the sleeve.

Guy wires connected by steel eyelets from the upper end of the outer revolving shaft to an eyelet set in each channel

iron arm about 16 inches from the free end, with turnbuckles interposed, took up the strain on the arms resulting from heavy plants on the platforms.

One of the platforms, in addition to the brass sprocket below, had a second sprocket 4 inches in diameter, screwed to the latter. This second sprocket was connected by a link chain to the sprocket of the collar screwed to the central steel axis. A steel ladder chain running around the outer teeth of each platform sprocket completed the table proper.

The apparatus was then connected up, by means of a reducing gear attached to the shaft of a ¼-horsepower motor and an intermediate series of sprockets and chains for further reduction of speed, with the large sprocket wheel below the central plate of the table. As the whole table turned on its axis, and the small sprocket screwed to the central steel shaft remained stationary, this resulted in a movement of the link chain connecting this shaft sprocket to the second one on one of the plant platforms; in consequence, this platform turned slowly on its axis, and by means of the ring of the ladder chain transmitted the revolution to the other platforms.

The table as a whole revolved about once every 45 seconds and each plant platform about once every minute. Wherever necessary, the sag of the chains was taken up by supporting them with fiber rollers.

Without exception the experiments were carried out in the greenhouse, and the potted plants used had in all instances been grown under approximately similar conditions and then well accustomed to the environment of the experimental section of the greenhouse. Before being used in the experiments all exposed portions of every pot were coated with paraffin or wax seal. A thistle tube for watering and a bent tube for the release of air pressure were inserted into the soil, and the pot was sufficiently watered before the soil was likewise covered with the seal. When placed upon the platform of the rotating table each pot rested upon a saucer. The use of the rotating table made it somewhat inconvenient to employ any type of auto-irrigator, or constant moisture device, though

very careful attention was given to watering. This was done at intervals sufficiently frequent and in such quantity as to maintain a fairly constant water relation. In the case of all potted plants, where the load was considerable, weighings were made to within 1 gram on a Troemner balance. Moreover, in carrying out the weighings the observer used the same sequence, beginning always with plant No. 1 and concluding the 8 weighings in 6–8 minutes. Therefore, the observation intervals varied by a maximum of less than 2 minutes for the plants in any series, so that with intervals generally greater than 1 hour such variations are entirely negligible.

As in our earlier work, and as followed by subsequent investigators, observations were made on the basis of several to many standardization intervals prior to spraying; that is, the rates of the plants to be sprayed and of those to remain as the control were first determined, furnishing a basis for a ratio between controls and those to be Bordeauxed. Then after the application of the sprays to the plants designated for these—allowing sufficient time for the complete drying of the films—observations were again made on the control and the sprayed plants for a suitable number of intervals.

Experimental

The experimental data are included in a series of tables arranged in a manner as uniform as possible. In the first column at the left of each table is recorded a number by means of which to identify the various time intervals, or "runs"; in the second column the actual period of time covered by the interval is included (likewise ratios computed from the remaining columns), and then follow 8 columns—for the 8 plants involved in each experiment—numbered in order and giving the transpiration quantities for each. The letters accompanying the numbers signify the treatment proposed or given; thus, during any standardization interval K = control, B = Bordeaux, BL = Bordeaux with excess of lime, L = a lime wash, and BC = Bordeaux with excess of the copper salt. Other letters will be explained in connection

with special tables. In order readily to distinguish the quantities in the after-standardization intervals, that is, in the intervals after the application of the spray, the letters are written K′, B′, BL′, etc.

The Bordeaux mixture was prepared as indicated in an earlier report, essentially the standard 4–6–50 formula of pathologists, while the mixture referred to as copper Bordeaux is the 6–4–50 formula, and that called lime Bordeaux is the standard Bordeaux diluted with an equal quantity of lime wash.

TABLE I

(Series A.—Potted potatoes)

EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1B*	2K†	3B	4K	5B	6K	7B	8K
I	8:20 A.M.–11:25 A.M. 1/9/17	19	20	13	11	13	22	15	8
	K:B = 61:60 = 1:.98	Sunshine							
II	11:25 A.M.–3:25 P.M. 1/9/17	27	30	23	15	19	33	22	15
	K:B = 93:91 = 1:.98	Sunshine							
III	3:25 P.M.–8:28 P.M. 1/9/17	6	4	6	6	3	7	7	5
	K:B = 22:22 = 1:1	Sunshine during early P.M. hours							
IV	8:28 P.M.–9:57 A.M. 1/10/17	16	13	17	10	7	16	18	11
	K:B = 50:58 = 1:1.16	Cloudy during early A.M. hours							
		1B′	2K′	3B′	4K′	5B′	6K′	7B′	8K′
V	4:00 P.M.–8:36 A.M. 1/11/17	49	11	38	15	24	17	52	17
	K′:B′ = 60:163 = 1:2.71	Sunshine at 4 P.M.							
VI	8:36 A.M.–12:31 P.M. 1/11/17	31	32	28	20	21	36	30	19
	K′:B′ = 107:110 = 1:1.03	Sunshine							
VII	12:31 P.M.–2:33 P.M. 1/11/17	21	28	17	14	15	24	21	14
	K′:B′ = 80:74 = 1:.93	Sunshine							

* B = Bordeaux mixture. † K = control.

If, in table 1, the total water loss of the intervals before spraying is compared with the total after spraying, the ratio changes from 1.02 to 1.4, a percentage increase of 37 per cent to be attributed to the Bordeaux film. However, in view of the possible effects of environmental conditions, it is of in-

terest to compare some single intervals which are more or less comparable from the standpoint of length of interval and weather conditions. On this basis we may compare interval IV before standardization with interval V immediately after

TABLE II

(Series B.—Potted potatoes)

EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.

DATA IN GRAMS

		1K	2B	3K	4B	5K	6BL*	7B	8BL
I	3:27 P.M.–4:59 P.M. 2/12/17	14	8	8	6	10	6	6	9
	K:B:BL = 32:20:15 = 1:.63:.47								
II	4:59 P.M.–7:07 A.M. 2/13/17	26	15	23	10	15	14	16	27
	K:B:BL = 64:41:41 = 1:.64:.64								
III	7:07 A.M.–1:10 P.M. 2/13/17	37	23	20	24	18	19	16	23
	K:B:BL = 75:63:42 = 1:.84:.56								
IV	1:10 P.M.–4:13 P.M. 2/13/17	17	17	15	16	17	11	12	16
	K:B:BL = 49:45:27 = 1:.92:.55								
V	4:51 P.M.–9:14 A.M. 2/14/17	16	11	17	9	16	10	14	18
	K:B:BL = 49:34:28 = 1:.69:.57								
VI	9:14 A.M.–1:53 P.M. 2/14/17	43	24	37	33	34	21	26	29
	K:B:BL = 114:83:50 = 1:.73:.44 Cloudy								
VII	1:53 P.M.–3:10 P.M. 2/14/17	8	4	5	7	4	5	4	5
	K:B:BL = 17:15:10 = 1:.88:.59 Cloudy								
VIII	3:10 P.M.–6:02 P.M. 2/14/17	8	1	7	5	4	5	3	7
	K:B:BL = 19:9:12 = 1:.47:.63 Cloudy								
IX	6:02 P.M.–9:35 A.M. 2/15/17	20	14	23	13	17	15	22	23
	K:B:BL = 60:49:38 = 1:.82:.63								
X	9:35 A.M.–1:21 P.M. 2/15/17	28	39	34	35	31	29	23	30
	K:B:BL = 93:97:59 = 1:1.04:.63								
XI	1:58 P.M.–4:52 P.M. 2/15/17	11	12	13	11	12	5	8	9
	K:B:BL = 36:31:14 = 1:.86:.39								
XII	4:52 P.M.–7:05 A.M. 2/16/17	10	5	6	5	7	7	9	6
	K:B:BL = 23:19:13 = 1:.83:.57								
XIII	7:05 A.M.–9:35 A.M. 2/16/17	46	40	36	31	18	33	22	7
	K:B:BL = 100:93:40 = 1:.93:.40 Sunshine								
XIV	1:26 P.M.–3:50 P.M. 2/16/17	17	20	16	19	15	14	11	12
	K:B:BL = 48:50:26 = 1:1.04:.54 Sunshine								

* BL = Bordeaux mixture with excess of lime.

TABLE II (Continued)
(Series B.—Potted potatoes)
EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1K′	2B′	3K′	4B′	5K′	6BL′	7B′	8BL′
XV	5:32 P.M.–7:10 A.M. 2/17/17	3	14	6	18	6	27	19	23
	K′:B′:BL′ = 15:51:50 = 1:3.4:3.3								
XVI	7:10 A.M.–1:20 P.M. 2/17/17	64	52	40	53	47	32	32	45
	K′:B′:BL′ = 151:137:77 = 1:.97:.51 Sunshine								
XVII	2:08 P.M.–7:57 P.M. 2/17/17	24	20	17	22	21	16	15	18
	K′:B′:BL′ = 72:57:34 = 1:.79:.47 Sunshine during early P. M. hours								
XVIII	7:57 P.M.–8:26 A.M. 2/18/17	2	10	9	10	6	10	10	10
	K′:B′:BL′ = 17:30:20 = 1:1.76:1.18								
XIX	8:26 A.M.–4:39 P.M. 2/18/17	29	27	19	23	13	14	15	18
	K′:B′:BL′ = 61:66:32 = 1:1.08:.52 Cloudy								
XX	7:10 A.M.–3:42 P.M. 2/19/17	31	56	61	52	35	47	29	34
	K′:B′:BL′ = 127:137:81 = 1:1.08:.64 Sunshine								

standardization, each interval extending throughout the night or somewhat longer. We then find that the ratio has changed from 1.16 to 2.71, or an increase of 133 per cent as a result of the surface film. During the second interval after standardization, VI, a day interval, the transpiration loss under conditions of continuous sunshine is very little more than during a similar interval, II, before standardization. Interval III before standardization is scarcely comparable with interval VII after standardization, but it is interesting to note that the increased water loss due to Bordeaux has now apparently disappeared, and the loss from these plants exhibits a ratio lower than in the control. Moreover, there is no interval after standardization which compares with the dull cloudy interval before standardization.

In table II considerable individual variation is exhibited, so that the relation of the K, B, and BL plants is not as constant as might be desired in the intervals before standardization. There seems to be a tendency for the K and BL loss to show a fair constancy, whereas the B plants frequently show a relatively high ratio during the day intervals and a

lower ratio during the night intervals. Since the conditions are the same for all the plants, this variation is unexplained. Leaving individual variation out of consideration, it will be seen that for the whole period of the observations the water loss is again higher for the plants sprayed with Bordeaux and lime Bordeaux than for the control. More interesting, however, are certain comparisons between single intervals before and after standardization. Assuming that the plants in the different lots before and after standardization are more nearly comparable in intervals which are relatively close together, we may compare the first interval after spraying, XV, which in other cases has shown marked increase as a result of the Bordeaux application, with interval XII before standardization, these two being night intervals of approximately equal length. Again, we find that the effect of the Bordeaux film during the first interval after spraying is very considerable, giving a percentage increase of 310, and that the Bordeaux lime preparation shows an increase of 479 per cent. On the other hand, if we compare the second interval after spraying under conditions of sunshine, XVI, with the last interval before spraying, XIV, we find a slightly diminished transpiration in the sprayed plants. The ratios of all subsequent intervals except one after spraying, XVII-XX, are nearly constant and approach the normal or average before standardization,—the exception being interval XVIII. The exceptional interval is a night period where again the ratio for sprayed plants is high. It seems well here to emphasize the fact that environmental conditions are obviously in some way important in determining the increased transpiration due to surface films.

The data given for series C in table III is noteworthy for several reasons. In the first place, it will be seen that in the several intervals of standardization the L group of plants exhibits a relative falling off in the rate of transpiration. There was no apparent cause for this, as the soil conditions were as moist as in the other pots, and evidence of flagging was entirely lacking. In the second place, after spraying the water loss of the B′ and BC′ plants is very great during interval

IV, this interval being largely a night period. During the next interval (a day period), with conditions bright and warm, there is practically a return to the normal or standardization rate for the B′ and BC′ plants as compared with

TABLE III
(Series C.—Potted tomatoes)
EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1K	2B	3BC*	4L†	5BC	6B	7K	8L
I	3:50 P.M.–9:10 A.M. 1/12/17	26	23	27	27	31	33	34	36
	K:B:BC:L = 60:56:58:63 = 1:.93:.97:1.05 Sunshine P.M.; cloudy A.M.								
II	9:10 A.M.–12:37 P.M. 1/12/17	28	29	25	20	29	33	29	29
	K:B:BC:L = 57:62:54:49 = 1:1.09:.95:.86 Sunshine, some clouds								
III	12:37 P.M.–3:44 P.M. 1/12/17	24	30	23	13	27	28	20	15
	K:B:BC:L = 44:58:50:28 = 1:1.33:1.14:.45 Sunshine, some clouds								
		1K′	2B′	3BC′	4L′	5BC′	6B′	7K′	8L′
IV	5:22 P.M.–9:13 A.M. 1/13/17	22	84	75	29	84	92	26	37
	K′:B′:BC′:L′ = 48:176:159:66 = 1:3.67:3.31:1.38 Sunshine A.M.								
V	9:13 A.M.–1:46 P.M. 1/13/17	41	45	40	32	38	31	40	29
	K′:B′:BC′:L′ = 81:76:78:61 = 1:.94:.96:.75 Sunshine, temperature high								
VI	3:37 P.M.–10:10 A.M. 1/14/17	32	61	55	33	57	59	37	34
	K′:B′:BC′:L′ = 69:120:112:67 = 1:1.74:1.62:.97 Sunshine, temperature high								
VII	10:10 A.M.–1:38 P.M. 1/14/17	29	34	23	21	20	16	25	28
	K′:B′:BC′:L′ = 54:50:43:49 = 1:.93:.80:.91 Sunshine, temperature high								
VIII	1:38 P.M.–5:09 P.M. 1/14/17	15	16	11	13	12	13	12	
	K′:B′:BC′:L′ = 27:29:23:(29 est.) = 1:1.07:.85:1.07 Sunshine, temp. high								
IX	5:09 P.M.–10:08 A.M. 1/15/17	16	52	45	28	30	35	18	
	K′:B′:BC′:L′ = 34:87:75:(60 est.) = 1:2.56:2.21:1.76 Cloudy A.M.								

* BC = Bordeaux with excess of the copper salt. † L = lime wash.

the control. Interval VI, again largely a twilight and night period, shows a rise in the rate in favor of the B′ and BC′ sprayed plants, followed again by day intervals in which the normal is approached. It was this series in particular, which was conducted prior to series B, which suggested so definitely the importance of conditions in modifying the amount of the transpiration quantities after spraying. In the preceding

discussion of ratios mention has not been made of the L lot of plants, but owing to the successive falling off in their rate of water loss during the standardization interval, it was felt that this lot could not be considered entirely normal. Never-

TABLE IV

(Series D.—Potted tomatoes)

EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1B	2Fe*	3B	4Fe	5Al†	6Mg‡	7Al	8Mg
I	8:31 A.M.–3:42 P.M. 1/19/17	21	29	20	18	36	26	27	28
	B:Fe:Al:Mg = 41:47:63:54 = 1:1.15:1.54:1.32 Sunshine								
II	3:42 P.M.–9:35 A.M. 1/20/17	11	12	11	7	12	13	11	13
	B:Fe:Al:Mg = 22:19:23:26 = 1:.86:1.05:1.18 Sunshine								
III	9:35 A.M.–11:17 A.M. 1/20/17	6	9	6	8	11	7	7	10
	B:Fe:Al:Mg = 12:17:18:17 = 1:1.42:1.5:1.42 Sunshine								
		1B′	2Fe′	3B′	4Fe′	5Al′	6Mg′	7Al′	8Mg
IV	1:50 P.M.–10:12 P.M. 1/20/17	16	17	16	15	25	35	22	34
	B′:Fe′:Al′:Mg′ = 32:32:47:69 = 1:1:1.47:2.16 Cloudy								
V	10:12 P.M.–12:45 P.M. 1/21/17	25	33	22	21	28	38	33	38
	B′:Fe′:Al′:Mg′ = 47:54:61:76 = 1:1.15:1.3:1.62 Intermittent sunshine								
VI	10:48 P.M.–9:24 A.M. 1/22/17	16	19	11	12	15	17	17	20
	B′:Fe′:Al′:Mg′ = 27:31:32:37 = 1:1.15:1.19:1.37								
VII	9:24 A.M.–3:15 P.M. 1/22/17	23	21	21	17	12	15	18	22
	B′:Fe′:Al′:Mg′ = 44:38:30:37 = 1:.86:.68:.84								

* Fe = film of ferric hydrate. † Al = film of aluminum hydrate. ‡ Mg = film of magnesium hydrate.

theless, it exhibits on the whole much the same change of ratio with change of conditions as the B′ and BC′ lots. Here again, as in our earlier experiments, the effect of the lime film has not generally been to increase the transpiration loss to the same extent as the copper films.

The data for series D are introduced with some hesitation, owing to the fact that at the close of the experiment all of the plants except one of those sprayed with Bordeaux mixture showed some injury, the extent of this being the wilting or death of from 1 to 4 leaves of each plant. Nevertheless,

some suggestions are evident as a result of this work. As compared with Bordeaux mixture, the films of iron, aluminum, and magnesium hydrate exhibit in the earlier intervals after standardization a rate which is on the whole equal to or greater than that of the Bordeaux-sprayed plants. In the last interval, however, there is a distinct falling off in all of

TABLE V

(Series E.—Potted tomatoes)

EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1B	2B	3RB*	4RB	5K	6K	7RB	8K
I	1:12 P.M.–4:49 P.M. 2/23/17	36	45	41	49	40	48	44	51
	K:B:RB = 139:81:134 = 1:.58:.96 Sunshine, becoming cloudy								
II	4:49 P.M.–7:00 A.M. 2/24/17	33	55	30	34	38	34	38	40
	K:B:RB = 112:88:102 = 1:.79:.91 Hazy at 7 A.M.								
III	7:00 A.M.–2:55 P.M. 2/24/17	93	73	77	66	63	86	117	91
	K:B:RB = 240:166:260 = 1:.69:1.08 Intermittent sunshine								
IV	3:25 P.M.–5:38 P.M. 2/24/17	5	2	4	3	3	2	5	4
	K:B:RB = 9:7:12 = 1:.78:1.33 Hazy								
V	5:38 P.M.–8:09 A.M. 2/25/17	29	28	28	25	25	32	35	31
	K:B:RB = 88:57:88 = 1:.65:1 Very hazy late P.M.								
		1B′	2B′	3RB′	4RB′	5K′	6K′	7RB′	8K′
VI	11:09 A.M.–5:36 P.M. 2/25/17	109	83	95	81	46	133	112	134
	K′:B′:RB′ = 313:192:288 = 1:.61:.92 Sunshine								
VII	5:36 P.M.–7:14 A.M. 2/26/17	11	6	7	7	4	8	10	4
	K′:B′:RB′ = 16:17:24 = 1:1.06:1.50								
VIII	7:14 A.M.–1:00 P.M. 2/26/17	49	29	32	34	18	55	47	45
	K′:B′:RB′ = 118:75:113 = 1:.64:.96 Sunshine								
IX	1:26 P.M.–4:22 P.M. 2/26/17	24	19	16	14	21	29	22	29
	K′:B′:RB′ = 79:43:52 = 1:.54:.66 Dull, becoming cloudy								
X	4:22 P.M.–7:10 A.M. 2/27/17	34	27	32	32	14	25	46	22
	K′:B′:RB′ = 61:61:110 = 1:1:1.80 Cloudy								
XI	7:44 A.M.–4:07 P.M. 2/27/17	44	35	29	32	45	61	35	58
	K′:B′:RB′ = 164:79:96 = 1:.48:.52 Cloudy								
XII	4:07 P.M.–7:11 A.M. 2/28/17	42	33	37	35	29	29	53	34
	K′:B′:RB′ = 92:75:125 = 1:.82:1.36								

* RB = red Bordeaux (erythrosin added).

the other lots as compared with the Bordeaux. It may perhaps be taken to suggest that the increased rate of transpiration of such films may in a measure be related to incipient injury, the rate being relatively high until this injury leads to wilting or death of a certain proportion of the leaves.

Series E was arranged with relatively old, potted tomato plants which had been cut back and had grown considerably "bunched." The greenhouse was maintained under the usual

TABLE VI

(Series F.—Potted marguerites)

EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1B	2R*	3B	4K	5R	6B	7K	8R
I	4:50 P.M.–9:25 A.M. 1/24/17	33	36	22	35	18	38	19	35
	K:B:R = 54:93:89 = 1:1.72:1.65								
II	10:10 A.M.–4 P.M. 1/24/17	124	129	121	147	57	135	75	158
	K:B:R = 222:380:344 = 1:1.71:1.55								
		1B′	2R′	3B′	4K′	5R′	6B′	7K′	8R′
III	4:47 P.M.–9:08 A.M. 1/25/17	15	24	17	12	23	27	14	18
	K′:B′:R′ = 26:59:65 = 1:2.27:2.5								
IV	10:18 A.M.–3:03 P.M. 1/26/17	61	75	54	60	72	72	86	67
	K′:B′:R′ = 146:187:214 = 1:1.28:1.47								

* R = resin Bordeaux.

conditions during intervals I–III and VIII–XII. During intervals IV–VII the walls and floors of the house were drenched morning and evening, and a small stream of water kept flowing through the house in an effort to maintain higher humidities. This was fairly successful except in interval VI, when the bright sunshine and high temperature made it difficult of accomplishment. During interval IV, moreover, the transpiration quantities are so small that the ratios are of questionable value. In this series three plants were treated with a reddened Bordeaux mixture, this being made by the addition of erythrosin to the usual Bordeaux until a deep red color was produced. The treated plants were sprayed copiously; in fact, until the mixture streamed from the plants.

Omitting from consideration the small values of interval IV, it is again evident that the outstanding feature of interest is the increased transpiration loss in both sets of sprayed plants during the night intervals. During intervals IX and XI the sprayed plants showed appreciable flagging, and this was doubtless sufficient to account for the low rate of those periods.

On the marguerites observations were made for a limited number of intervals. The plants were in vigorous condition, about 37 cm. high and beginning to blossom. From a pre-

TABLE VII
(Series G.—Tobacco)
EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1B	2K	3B	4K	5B	6K	7B	8K
I	4:30 P.M.–5:32 P.M. 1/17/18	4	8	3	9	5	6	3	2
	K:B = 25:15 = 1:.60	Bright at 4:30							
II	5:32 P.M.–7:34 P.M. 1/17/18	6	10	10	2	4	8	3	2
	K:B = 22:23 = 1:1.05								
III	7:34 P.M.–10:34 P.M. 1/17/18	6	10	11	10	5	11	2	4
	K:B = 35:24 = 1:.69								
IV	10:34 P.M.–7:01 A.M. 1/18/18	15	26	21	29	15	32	11	10
	K:B = 97:62 = 1:.64								
V	7:34 A.M.–8:41 A.M. 1/18/18	2	5	3	7	2	6	2	3
	K:B = 21:9 = 1:.43	Sunshine by 8 A.M.							
VI	8:41 A.M.–9:41 A.M. 1/18/18	6	5	6	7	8	8	2	8
	K:B = 28:22 = 1:.79	Sunshine							
VII	9:41 A.M.–10:41 A.M. 1/18/18	11	12	9	11	11	11	8	8
	K:B = 42:39 = 1:.93	Sunshine							
VIII	10:41 A.M.–11:41 A.M. 1/18/18	12	16	15	17	22	15	15	15
	K:B = 63:64 = 1:1.02	Sunshine							
IX	11:41 A.M.–12:41 P.M. 1/18/18	13	18	12	19	15	14	7	15
	K:B = 66:47 = 1:.71	Sunshine							
X	12:41 P.M.–1:41 P.M. 1/18/18	11	18	13	16	15	17	10	12
	K:B = 63:49 = 1:.78	Sunshine							
XI	2:00 P.M.–3:00 P.M. 1/18/18	11	15	10	17	11	14	11	14
	K:B = 60:43 = 1:.72	Sunshine							

TABLE VII (Continued)

		1B′	2K′	3B′	4K′	5B′	6K′	7B′	8K′
XII	4:30 P.M.–5:30 P.M. 1/18/18	12	5	10	4	13	4	12	0
	K′:B′ = 13:47 = 1:3.62								
XIII	5:30 P.M.–7:32 P.M. 1/18/18	9	2	12	4	13	4	10	0
	K′:B′ = 10:44 = 1:4.4								
XIV	7:32 P.M.–10:32 P.M. 1/18/18	13	4	8	3	19	4	15	2½
	K′:B′ = 13.5:55 = 1:4.07								
XV	10:51 P.M.–7:15 A.M. 1/19/18	31	10	24	7	40	9	32	8
	K′:B′ = 34:127 = 1:3.74								
XVI	7:44 A.M.–8:44 A.M. 1/19/18	9	7	5	7	4	9	5	4
	K′:B′ = 27:23 = 1:.85	Glass frosted during this interval							
XVII	8:44 A.M.–9:44 A.M. 1/19/18	9	8	7	10	10	8	9	6
	K′:B′ = 32:35 = 1:1.09	Sunshine							
XVIII	9:44 A.M–10:44 A.M. 1/19/18	14	17	11	14	15	15	14	14
	K′:B′ = 60:54 = 1:.90	Sunshine							
XIX	10:44 A.M.–11:45 A.M. 1/19/18	9	11	9	15	14	9	12	13
	K′:B′ = 48:44 = 1:.92	Cloudy during most of interval							
XX	11:45 A.M.–12:45 P.M. 1/19/18	13	14	10	8	12	14	8	13
	K′:B′ = 49:43 = 1:.88	Cloudy							
XXI	12:45 P.M.–1:49 P.M. 1/19/18	11	13	12	13	12	11	11	11
	K′:B′ = 48:46 = 1:.96	Cloudy							
XXII	1:49 P.M.–2:50 P.M. 1/19/18	7	7	4	9	3	7	6	7
	K′:B′ = 30:20 = 1:.67	Cloudy							
XXIII	2:50 P.M.–3:50 P.M. 1/19/18	7	4	2	2	9	5	6	2
	K′:B′ = 13:24 = 1:1.85	Cloudy							

liminary trial it was seen that the usual Bordeaux mixtures would not adhere well, so that in addition to this a resin Bordeaux was employed. All treated plants were sprayed heavily. The transpiration quantities were remarkably uniform in the standardization intervals, and after spraying the increased transpiration for the sprayed plants was considerable, the ratio for Bordeaux changing from 1:.71 to 1:2.27. The group treated with the resin Bordeaux gave somewhat greater transpiration loss during the same interval. Unfortunately, after this first interval, and with the higher temperature of the greenhouse during the day, injury began to

be manifested in all of the sprayed plants, leading immediately to a falling off in the rate. The edges of the lower leaves dried out rapidly and it was necessary to discontinue the series.

It seemed desirable to employ in one series some broad-leaved, fairly succulent plant, and at the same time to make several observations during the evening or night interval in order to control more completely the previous experiments, as a result of which the night intervals of sprayed plants had almost invariably shown the highest transpiration ratios. The results of series G are particularly interesting. It is felt, however, that the variability exhibited by the different groups of plants during, say, the first four to six intervals, indicates a lack of adjustment to the new conditions; and perhaps it would be best to regard the last five intervals of the standardization period (VII–XI) as expressing more nearly the true ratio of the two groups of plants.

The plants were sprayed moderately, and, as will be noted, three observations were made between 4:30 and 10:30 P. M. From the results noted in intervals XII–XIV there was, after

TABLE VIII

(Series H.—Potted Cyperus)

EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1B	2K	3B	4K	5B	6K	7B	8K
I	10:00 A.M.–11:00 A.M. 10/25/17	18	18	----	15	21	12	18	11
	K:B = 56:57 = 1:1.02	Cloudy							
II	11:00 A.M.–12:04 A.M. 10/25/17	13	16	----	12	18	9	12	2
	K:B = 39:43 = 1:1.10	Cloudy							
III	12:04 A.M.–1:00 P.M. 10/25/17	16	19	----	15	18	12	19	10
	K:B = 56:53 = 1:.95	Cloudy							
IV	1:00 P.M.–2:09 P.M. 10/25/17	12	13	----	13	17	17	5	1
	K:B = 44:34 = 1:.77	Cloudy							
V	2:09 P.M.–3:08 P.M. 10/25/17	11	11	----	11	17	6	13	8
	K:B = 36:41 = 1:1.14	Cloudy							
VI	4:01 P.M.–7:15 A.M. 10/26/17	44	52	----	32	61	50	28	24
	K:B = 158:133 = 1:.84	Cloudy							

TABLE IX

(Series J.—Castor bean leaves)

EFFECT OF BORDEAUX MIXTURE ON THE RATE OF TRANSPIRATION.
DATA IN GRAMS

		1K	2B	3K	4B	5K	6B	7K	8B
I	10:46 A.M.–11:18 A.M. 9/24/17	2.6	5.0	8.7	9.1	0.3	8.4	5.1	8.8
	K:B = 16.7:31.3 = 1:1.87	Sunshine							
II	11:18 A.M.–11:48 A.M. 9/24/17	7.1	6.9	13.4	8.0	1.0	12.2	6.5	11.8
	K:B = 28.0:38.9 = 1:1.35	Sunshine							
III	11:48 A.M.–12:18 P.M. 9/24/17	5.1	7.7	11.5	6.6	1.0	14.5	7.9	12.2
	K:B = 25.5:41.0 = 1:1.61	Sunshine							
IV	12:18 P.M.–12:49 P.M. 9/24/17	11.2	6.5	7.0	5.5	1.3	10.3	6.2	9.0
	K:B = 25.7:31.3 = 1:1.22	Sunshine							
V	12:49 P.M.–1:45 P.M. 9/24/17	6.4	14.3	7.5	8.9	1.1	22.1	15.7	18.1
	K:B = 30.7:63.4 = 1:2.07	Sunshine							
		1K′	2B′	3K′	4B′	5K′	6B′	7K′	8B′
VI	3:21 P.M.–3:55 P.M. 9/24/17	1.2	6.2	3.2	4.2	0.7	12.3	8.0	8.6
	K′:B′ = 13.1:31.3 = 1:2.39	Sunshine							
VII	3:55 P.M.–4:29 P.M. 9/24/17	1.3	6.1	3.5	4.0	1.0	9.1	4.2	6.6
	K′:B′ = 10.0:25.8 = 1:2.58	Sunshine							
VIII	4:29 P.M.–5:04 P.M. 9/24/17	0.3	4.0	1.4	2.9	0.8	6.9	3.6	5.7
	K′:B′ = 6.6:19.5 = 1:2.95	Sunshine							
IX	5:04 P.M.–7:06 P.M. 9/24/17	1.6	7.0	2.1	5.8	2.0	12.1	5.5	8.3
	K′:B′ = 11.2:33.2 = 1:2.96								
X	7:06 P.M.–9:08 P.M. 9/24/17	1.7	4.0	1.3	5.2	1.5	6.9	4.0	5.1
	K′:B′ = 8.5:21.2 = 1:2.49								
XI	9:08 P.M.–7:03 A.M. 9/25/17	3.3	4.5	1.6	5.4	2.2	8.5	4.1	6.6
	K′:B′ = 11.2:25.0 = 1:2.23								
XII	7:03 A.M.–9:10 A.M. 9/25/17	1.6	11.4	5.0	8.5	1.4	7.5	10.4	15.0
	K′:B′ = 18.4:42.4 = 1:2.34	Weak sunshine							
XIII	9:10 A.M.–10:14 A.M. 9/25/17	2.9	11.2	2.4	7.1	1.3	21.4	11.9	18.4
	K′:B′ = 18.5:58.1 = 1:3.14	Sunshine							
XIV	10:14 A.M.–11:09 A.M. 9/25/17	3.6	7.3	2.2	7.1	1.2	23.1	14.4	21.3
	K′:B′ = 21.4:58.8 = 1:2.75	Sunshine							

It had been intended to repeat the experiments with excised leaves under various environmental conditions, but the high temperature prevailing when the material was ready in the

early fall rendered this impossible. Leaves of the castor bean, which in our earlier work had been found favorable for studies of this kind, were procurable in large number, but under the conditions maintaining in the greenhouse they proved subject to great fluctuations and to severe wilting. In many cases the leaves wilted in test chambers where the atmosphere was kept fairly moist, and the indications were that the cause might lie in the movement of viscous materials into the conducting channels. Nevertheless, one completed series was maintained under satisfactory conditions and the results are shown in table IX. The leaf stems were inserted through one mouth of a Wolff bottle into a weak Crone solution, movement of the leaves with the rotation of the table, when this occurred, being prevented by means of a lump of plasticene. In this case, however, weighings were made on a trip balance, weighing accurately to .1 gram.

From the data presented it will be seen that the sprayed plants exhibit an increase in the transpiration loss throughout all intervals of the experiment. In this case the increased water loss in the night interval is no more pronounced than during any other interval. The results here are in complete accord with those previously reported from this laboratory, and it would seem reasonable to anticipate that some general explanation may be advanced to account for the striking differences noted in these experiments as between excised leaves, on the one hand, and potted plants, such as the potato, tomato, and tobacco, on the other.

Discussion and Summary

The data presented in this paper offer a mass of additional proof to establish the point that a film of Bordeaux mixture or of certain other materials of similar physical characteristics influence, often to a marked degree, the rate of water loss from the plant. Although the work accomplished does not yet include as many types of plants as might be wished, nor are the conditions of the environment so completely measured or controlled that the relation of this increased water loss to environmental factors may be clearly defined, yet that both

plant type and summation of conditions are factors of importance seems a well-warranted conclusion, as will be developed below.

The results may be discussed in three categories, in respect to the plant material employed. In the first type of material the usual mesophytic potted plant has constituted the experimental object; in the second, a plant of xerophytic surface modifications, *Cyperus esculentus;* and third, abscised leaves of castor beans. Without exception, the potted plants in the first category furnished consistent evidence that under the conditions of our experiments increase in the rate of transpiration occurs mainly, if not entirely, during the night intervals. There may be little or no change in the rate of transpiration during the day intervals, and, to a considerable extent, at least, this is independent of slight changes in weather conditions,—some of the experiments having been conducted in bright sunshine, others in cloudy weather, and in still other cases different intervals in the same series have furnished varied conditions. Nevertheless, the fact that the night interval has invariably exhibited, in respect to the sprayed plants, a transpiration increase, makes it clear that in some way the sum of night and day conditions is responsible for the increased water loss. Attempts to increase or diminish the humidity in the greenhouse by flooding with water has not resulted in any indications which alone might explain the observed phenomenon.

The greenhouse was subject to a rise and fall of temperature from midnight to midday, amounting to from 7 to 15° C. It has repeatedly been noticed that under such greenhouse conditions seedlings exhibit the phenomenon of guttation to some degree, often to a very high degree. Now if it may be assumed that the potted plants experimented upon were subject each night to conditions inducing guttation, or at least incipient guttation, this condition might be made use of to explain the phenomenon in the following way: A film of Bordeaux mixture on the surface of a plant in a state of guttation would probably act more or less as a bibulous surface, taking water directly from the interior of the plant, through

at least some continuous water channels established by means of the open water-suffused stomata. Under such conditions it seems fair to assume that the water would spread through the film of Bordeaux mixture, and the evaporating surface would thereby be greatly increased. On the other hand, during the day, as this state of incipient guttation might give way to a condition in which the interchange between the inner and outer atmosphere is governed wholly by the diffusion of water vapor, the presence of an absorbent surface film would have little, or at least far less, power to increase the evaporating surface, or in any other known manner to facilitate evaporation.

Again, taking the case of *Cyperus,* an explanation of the failure of the surface film to increase the transpiration rate might then be found both in the fact that the stomatal openings are exceedingly small, and that the air space of the leaf tissue is very limited in extent. In all probability, with such material, a state approaching guttation would be realized with great difficulty, if at all, and a "clogging" of the stomata might indeed tend to inhibit transpiration.

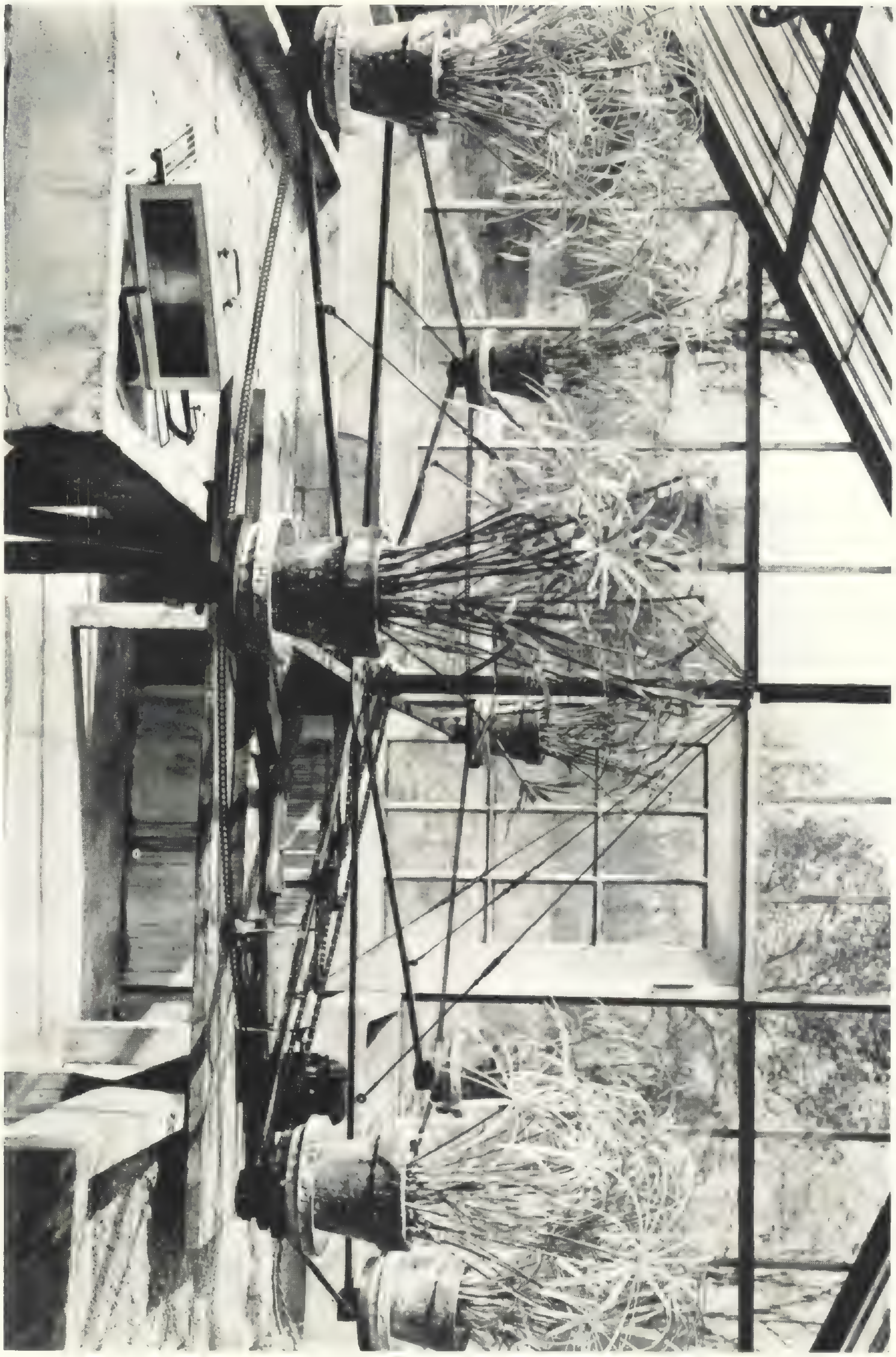
The excised leaves which are able to maintain themselves at all might be expected to exhibit very different water relations, and it is not possible from the data at hand to conclude that in this case there is in reality any possibility of a state of incipient guttation. This is, however, possible. At any rate, the writers have found no satisfactory explanation of the results obtained except the one just discussed. Some phases of this explanation are susceptible of direct experimentation and in further work it is proposed to subject the matter to critical test. For the present it is offered as a suggestion merely.

Graduate Laboratory, Missouri Botanical Garden.

Explanation of Plate

PLATE 10

General view of rotating "table" arranged with *Cyperus*. The thermo-hygrograph employed—removed from sheltered stand—is also shown.



DUGGAR AND BONNS—RATE OF TRANSPIRATION

Annals
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THE THELEPHORACEAE OF NORTH AMERICA. IX[1]

ALEURODISCUS

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ALEURODISCUS

Aleurodiscus Rabenhorst, Fungi Eur. Exs., 1824 (without diagnosis). 1874; Hedwigia **13** : 184 (without diagnosis). 1874; Schroeter, Krypt.-Fl. Schlesien **3** : 429. 1888; Engl. & Prantl, Nat. Pflanzenfam. (**1.1****) : 120. 1898; Patouillard, Essai Taxon. Hym. 52. 1900; v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116** : 793. *pl. 1–4.* 1907; Bourd. & Galz. Soc. Myc. Fr. Bul. **28** : 349. 1913.

Fructifications resupinate, sometimes with margin free all around and somewhat saucer-shaped, rarely dimidiate and attached by the base, drying coriaceous; hymenium pulverulent; paraphyses noteworthy, modified into forms such as moniliform, or racemose by presence of short lateral branches —these paraphyses are sometimes called dendrophyses; granular or crystalline matter often in great quantity between the basidia, paraphyses, and hyphae of the fructification; basidia simple, usually large and with four large sterigmata; spores simple, usually large, with colorless cell wall.

The type species is *Aleurodiscus amorphus* (Pers.) Rabenh. originally published as *Peziza amorpha* by Persoon, then transferred to *Thelephora* by Fries when known to be a basid-

[1] Issued September 20, 1918.

iomycete, and finally referred by Fries with doubt to *Corticium* and regarded by Quelet as a *Cyphella.*

Into *Aleurodiscus* have been assembled species of related structure which were originally published in *Corticium* and *Stereum* on the basis of form of fructification, but which are noteworthy by basidia and spores often enormous in dimensions for the genera to which these species were originally referred, and which sometimes have paraphyses of remarkable form, and the fructification greatly thickened in some species by so large an amount of incrusted or granular matter as to render it very difficult to make out the detailed structure of basidia and paraphyses in good sectional preparations. The granular and crystalline matter may be dissolved from the sections by warming them on the slide in a few drops of dilute hydrochloric acid, but with the disadvantage of leaving the paraphyses and other organs with rather vague outlines, as though somewhat collapsed or disorganized.

Some species now referred to *Aleurodiscus* are intermediate between this genus and other genera by the absence of any notable development of some one or other of the foregoing characters, and it is too largely a matter of personal opinion as to just which species should be transferred. On the whole, *Aleurodiscus* is probably useful, although bound to be a source of confusion by introducing into a scheme of classification based upon form and general structure of fructification a conflicting scheme of classification based upon rather trivial, and often poorly shown, features of microscopic detail, with disregard of diversity in form and general structure of fructification involved. Innovations of this kind should certainly be exceptional.

Of the 25 species of *Aleurodiscus* which have been recognized up to the present time, 14 occur in North America, 8 in Europe, 5 in Asia and Australia, 2 in Africa, and 2 in South America. *A. acerinus* is the only one of these which is of world-wide distribution; *A. amorphus* is the only other species common to both Europe and North America, and in North America it is restricted to northern United States and Canada. Only 3 species, *A. acerinus, A. candidus,*

and *A. nivosus*, have wide range in the United States. Our other species are local: 7 comprise the total for New England, 7 are subtropical or tropical, and 5 are present in the Rocky Mountain states or westward.

Key to the Species

Fructifications discoid, cup-shaped, pezizaeform, as in *A. amorphus*..... 1

Fructifications normally effuso-reflexed, sometimes with margin free all around, as in *A. Oakesii*, sometimes barely showing color of under side, as in *A. candidus*, which is often strictly resupinate..... 2

Fructifications resupinate, effused, the margin never reflexed..... 3

1. Spores minutely echinulate; paraphyses moniliform; free margin of fructification light-colored on under side; on balsam fir and spruce..... *1. A. amorphus*

1. Spores even; paraphyses of bottle-brush form; free margin of under side of fructification deep mouse-gray; on hemlock in New England and New York ..... *2. A. Farlowii*

1. Spores even; some paraphyses of bottle-brush form, others with moniliform tips; margin of under side of fructification light-colored; on *Ostrya* and other frondose species..... *3. A. Oakesii*

2. Spores even; some paraphyses of bottle-brush form, others with moniliform tips ..... *3. A. Oakesii*

2. Spores minutely echinulate, apiculate; many paraphyses of bottle-brush form, none moniliform; sometimes resupinate; Jamaica to Grenada ..... *4. A. apiculatus*

2. Spores even; paraphyses with somewhat corymbosely branched, filiform tips, made out with great difficulty because of the large amount of incrusting and crystalline matter present; fructification chalk-white, orbicular; sometimes resupinate..... *5. A. candidus*

3. Fructifications drying between antimony-yellow and yellow-ocher at the surface, white within, staining herbarium sheets and envelopes yellow ..... *6. A. strumosus*

3. Fructifications not egg-yellow 4

4. Paraphyses heavily loaded with incrusting matter, so that their branching is not easily made out, not of bottle-brush form..... 5

4. Paraphyses with short lateral prongs, i. e., of bottle-brush form, and not organs for carrying heavy incrustation..... 6

5. Paraphyses filiform, spirally twisted or flexuous; spores even, 11–18×9½–13 μ; globose organs staining brown with iodine, 6–15 μ in diameter, scattered throughout the fructification; in Cuba and Jamaica..*7. A. seriatus*

5. Paraphyses with corymbosely branched tips; spores even, 15–20×12–16 μ; gloeocystidia clavate, 18–30×9 μ; fructifications white; on bark of living cedar trees..... *8. A. nivosus*

5. Paraphyses with racemosely branched tips; spores even, 10–12×6–7 μ; gloeocystidia not present..... *9. A. acerinus*

6. Spores even 7

6. Spores minutely echinulate..... 8

7. Bottle-brush portions of paraphyses 10–15×3–4½ μ over lateral prongs; spores 13–15×9–11 μ; on *Rubus* and *Vitis* in Massachusetts, Maryland, and Mexico..... *10. A. botryosus*

7. Bottle-brush portions 15×6 μ over lateral prongs; spores globose, 9 μ in diameter; fructifications cream-buff, 600–800 μ thick, zonate with crystalline matter; on *Quercus* in New Mexico..... *11. A. cremeus*

8. Bottle-brush structure disorganized by KHO solution; spores 12–15×9–12 μ; fructifications white, 60–90 μ thick; on frondose wood in Cuba ..... *12. A. tenuis*

8. Paraphyses flexuous, 6 μ in diameter, some of them with a cluster of prongs at the tips; spores subglobose, 15–20 μ in diameter; on *Tsuga* and *Pseudotsuga* in Idaho and westward..... *13. A. penicillatus*

8. Bottle-brush organs about 23×12 μ, cockroach-shaped; spores subglobose, 6–12 μ in diameter; on *Abies*, *Thuja*, and *Larix* in Idaho and British Columbia..... *14. A. Weirii*

1. A. amorphus (Pers.) Rabenhorst, Fungi Eur. Exs., 1824. 1874; Hedwigia **13** : 184. 1874; Cooke, Grevillea **3** : 136. 1875; Schroeter, Krypt.-Fl. Schlesien **3** : 429. 1888; v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116** : 799. *pl. 1. f. 2.* 1907; Bourd. & Galz. Soc. Myc. Fr. Bul. **28** : 350. 1913.

Peziza amorpha Persoon, Syn. Fung. 657. 1801; Myc. Eur. **1** : 269. 1822.—*Thelephora amorpha* (Pers.) Fries, Elenchus Fung. **1** : 183. 1828.—*Corticium amorphum* (Pers.) Fries, Epicr. 559. 1838; Hym. Eur. 648. 1874; Sacc. Syll. Fung. **6** : 606. 1888.—*Cyphella amorpha* (Pers.) Quelet, Ench. Fung. 215. 1886.—*Nodularia balsamicola* Peck, N. Y. State Mus. Rept. **24** : 96. *pl. 4. f. 23–26.* 1872.

Illustrations: De Bary, Comp. Morph. and Phys. Fungi, *f. 30;* Hennings in Engl. & Prantl, Nat. Pflanzenfam. (**1.1****) : *f. 67, C–D;* v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116**[5]: *pl. 1. f. 2;* Patouillard, Tab. Anal. Fung. *f. 584;* Peck, N. Y. State Mus. Rept. **24** : *pl. 4. f. 23–26.*

Fructifications disk-shaped, scattered or sometimes confluent, somewhat fleshy, drying coriaceous, attached by a point, the margin free, elevated, incurved; hymenium convex, pulverulent, buff-pink at first, becoming deep olive-buff in the herbarium, the margin paler; in structure 500–1000 μ thick, composed of densely interwoven, hyaline hyphae 3 μ in diameter, granule-incrusted and with the granules crystalline and sometimes up to 12 μ in diameter but not so numerous as to conceal the structure of the fructification; paraphyses hyaline, filiform, flexuous, often moniliform, 4–4½ μ in diameter; basidia clavate, large, 120×18 μ, with four large sterigmata; spores subglobose with hyaline wall, minutely echinulate, 20–27×16–21 μ.

Fructifications 1–3 and 4 mm. in diameter, ½–1 mm. thick where not attached, 2 mm. thick where attached.

On balsam fir, spruce, and *Thuja plicata*. Newfoundland to New York and westward to Oregon. Infrequent.

The aspect of *A. amorphus* is that of a small *Peziza*, which may account for the infrequency of this species in the collections which have been sent to me for determination. The large, minutely spinulose spores and moniliform paraphyses are distinguishing microscopic characters. The echinulate marking of the spores is very faint in the collections from Idaho westward.

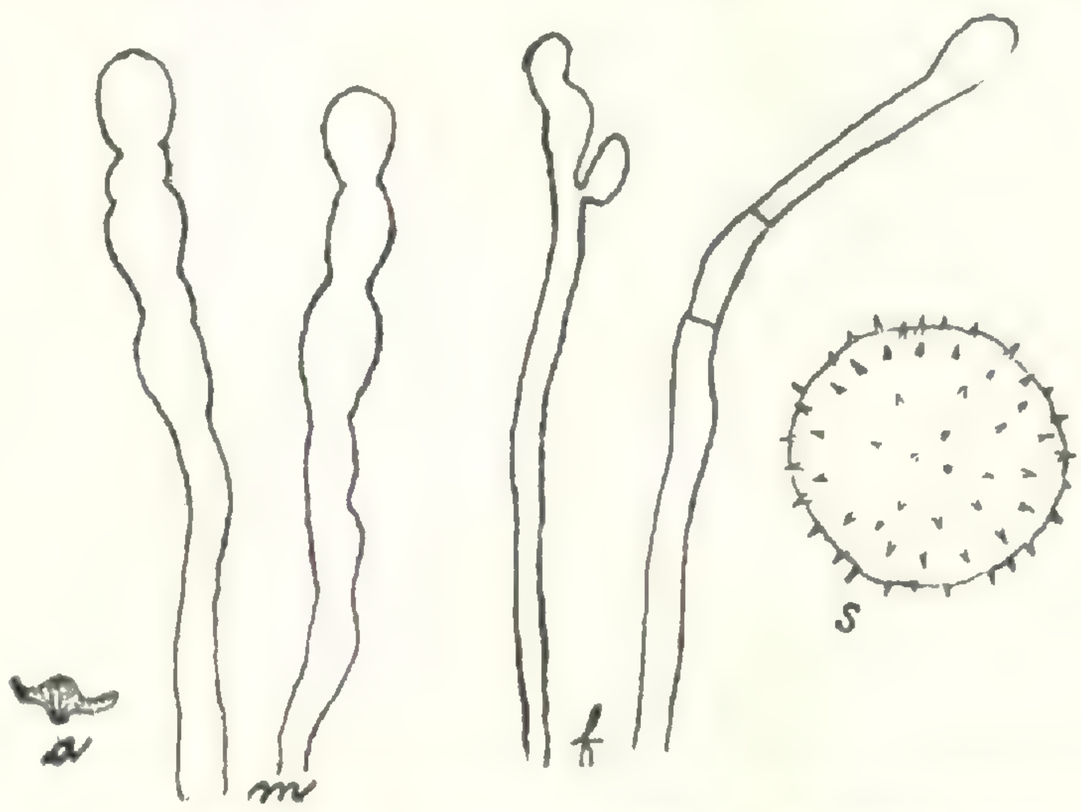

Fig. 1. A. amorphus. Section of fructification showing tubercular base of attachment, *a*, ×2; moniliform paraphyses, *m*; flexuous paraphyses, *f*; and spore, *s*. ×870.

Specimens examined:

Exsiccati: Ell. & Ev., N. Am. Fungi, 2733; Krieger, Fungi Sax., 619, 1908; Oudemans, Fungi Neerlandici Exs., 285; Romell, Fungi Scand. Exs., 130; de Thümen, Myc. Univ., 1508 (in Burt copy but not in Mo. Bot. Gard. Herb. copy), under the name *Dasyscypha calycina*.

Sweden: Omberg, *G. Schotte*, in Romell, Fungi Scand. Exs., 130.

Germany: Saxony, Königstein, *W. Krieger*, in Krieger, Fungi Sax., 619; Schandau, *W. Krieger*, in Krieger, Fungi Sax., 1908.

Switzerland: Neuchatel, *P. Morthier*, in de Thümen, Myc. Univ., 1508.

Holland: in Oudemans, Fungi Neerlandici Exs., 285.

France: *Fautrey* (in Lloyd Herb., 4353).

Newfoundland: Frenchman's Cove, *A. C. Waghorne, 319* (in Mo. Bot. Gard. Herb.).

Prince Edward's Island: Rustico Bay, *J. Macoun, 342.*

Ontario: Lake Nipigon, *J. Macoun.*

New Hampshire: Camp, Ellis R., *U. & C.*, from Underwood Coll. (in N. Y. Bot. Gard. Herb. and in Mo. Bot. Gard. Herb., 4773); Chocorua, *W. G. Farlow;* Shelburne, *W. G. Farlow* (in Mo. Bot. Gard. Herb., 4772).

New York: Adirondack Mts., *S. L. Clarke* (in N. Y. Bot. Gard. Herb.); Lake Placid, *W. A. & Edna L. Murrill, 209, 1127* (in N. Y. Bot. Gard. Herb.); East Galway, *E. A. Burt;* Indian Lake, *C. H. Peck,* type of *Nodularia balsamicola* (in Coll. N. Y. State and N. Y. Bot. Gard. Herb.); Willsboro, Essex Co., *C. O. Smith.*

Michigan: Vermilion, *A. H. W. Povah, 198* (in Mo. Bot. Gard. Herb., 13634).

Wisconsin: Madison, *Miss A. O. Stucki, 55,* Univ. of Wisconsin Herb.

Idaho: Pend d'Oreil, *J. B. Leibig,* in Ell. & Ev., N. Am. Fungi, 2733; Priest River, *J. R. Weir, 311, 358* (in Mo. Bot. Gard. Herb., 7065 and 10229 respectively).

British Columbia: Sidney, *J. Macoun, 29, 31* (in Mo. Bot. Gard. Herb., 6773 and 6774 respectively).

Washington: Chehalis, *C. J. Humphrey, 5276;* Olympic Mts., *T. C. Frye, 18* (in Farlow Herb., N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 44301).

Oregon: Mt. Hood, *T. C. Frye, 15* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55444); Forest Grove, *A. R. Sweetser.*

2. **A. Farlowii** Burt, n. sp.

Type: in Farlow Herb. and Burt Herb.

Fructifications disk-shaped, scattered or sometimes confluent, coriaceous, attached by a point or tubercle, the margin free, incurved, under side deep mouse-gray; hymenium convex, pulverulent, avellaneous at first, becoming drab in the herbarium; in structure, with the hyphae arising from the substratum, hyaline, even, thick-walled, densely interwoven, 3 μ in diameter, not incrusted, then radiating outward in all directions to form the hymenium, made up of basidia and paraphyses, with the latter extending about 30 μ beyond the basidia; paraphyses of the racemose kind, resembling hya-

line bottle brushes, 6–7 μ in diameter over branches, with central axis bearing along its whole length short lateral branches of equal length, densely crowded together; basidia clavate, 36–54×9–12 μ; spores hyaline, even, flattened on one side, 13–18×9–12 μ.

Fructifications 1–1½ mm. in diameter, unless elongated by confluence of two or three, about ½ mm. thick.

On dead twigs of hemlock, perhaps on balsam fir also. New Hampshire and New York. Rare.

A. Farlowii has the general aspect of *A. amorphus* but may be separated from this species when examined superficially, by its smaller fructifications, which are nearly black on the unattached part of the under side, while those of the larger species are light-colored; the small basidia, small spores, bottle-brush paraphyses, and absence of incrusting matter afford additional decisive characters. *A. Oakesii* has bottle-brush paraphyses which are of greater diameter than those of *A. Farlowii* and with fewer branches and its fructifications are much larger and of a different form.

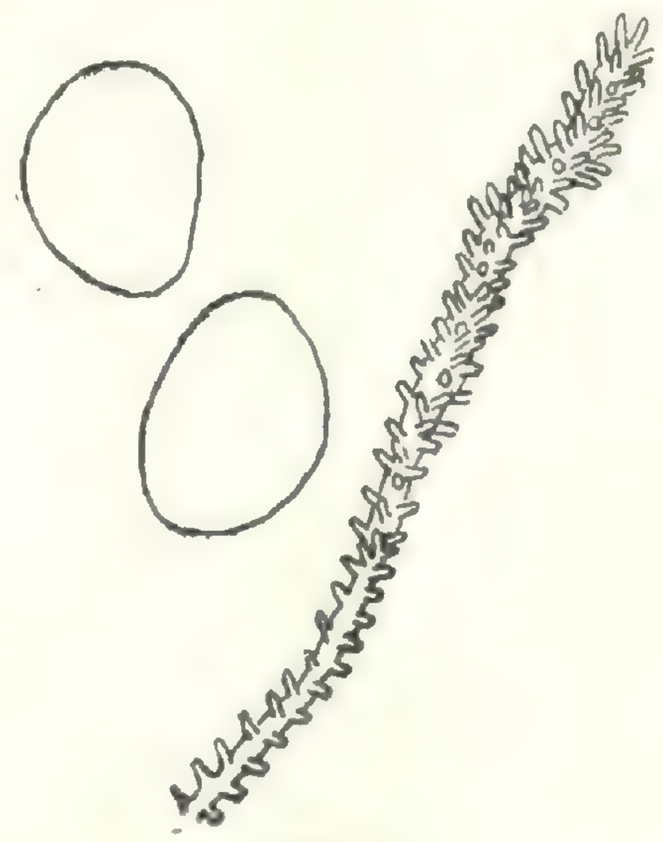

Fig. 2
A. Farlowii.
Two spores and bottle-brush paraphysis. ×870.

Specimens examined:

New Hampshire: Chocorua, *W. G. Farlow;* King's Ravine, *W. G. Farlow,* type.

New York: Vaughns, Hudson Falls, *S. H. Burnham, 21,* and *an unnumbered collection* (in Mo. Bot. Gard. Herb., 44014 and 44121 respectively).

3. A. Oakesii (Berk. & Curtis) Cooke, Grevillea **3**: 172. 1875; v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116**: 802. *pl. 3. f. 1.* 1907.

Corticium Oakesii Berk. & Curtis, Grevillea **1**: 166. 1873; Sacc. Syll. Fung. **6**: 606. 1888; Pierce, Torr. Bot. Club Bul. **17**: 301. *pl. 110. f. a–i.* 1890.

Illustrations: Patouillard, Rev. Myc. **12**. *pl. 107 bis. f. 5a, d;* Pierce, Torr. Bot. Club Bul. **17** : *pl. 110. f. a–i;* v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116** : *pl. 3. f. 1.*

Type: type distribution in Ravenel, Fungi Car. **3** : 32.

Fructifications disk-shaped, pezizaeform, scattered or confluent, somewhat fleshy, drying coriaceous, attached by the

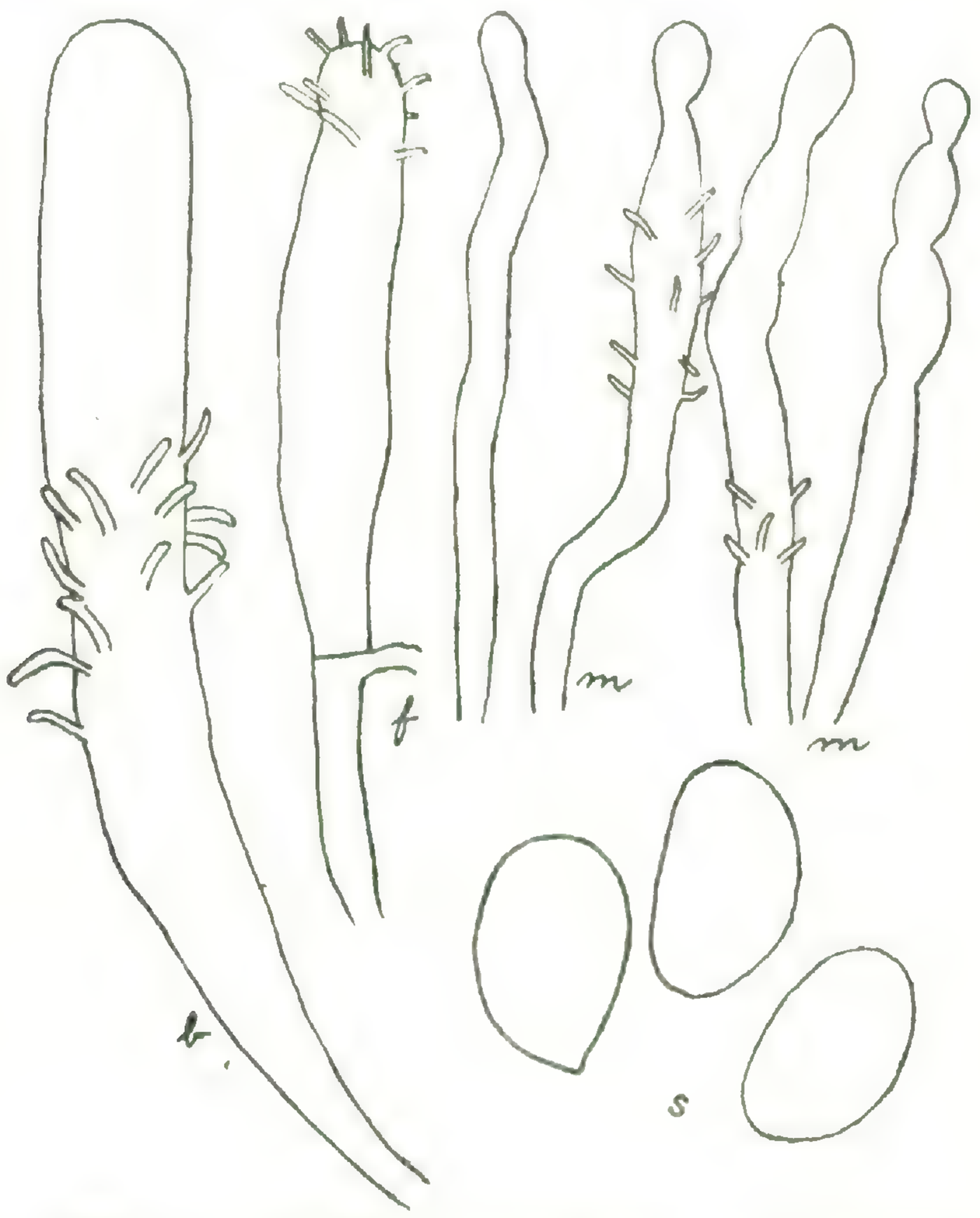

Fig. 3. A. Oakesii. Immature basidium, *b;* flexuous paraphyses, *f;* moniliform paraphyses, *m,* some with whorl-like clusters of lateral, bottle-brush prongs; spores, *s.* ×870.

center, the margin free, elevated, incurved, whitish and tomentose on the under side; hymenium concave, pulverulent, drying avellaneous; in structure about 600 μ thick, composed of hyaline hyphae 3–3½ μ in diameter, rather thick-walled, sometimes granule-incrusted, longitudinally arranged and interwoven next to the substratum, curving outward to bear the hymenium, consisting of basidia and filiform paraphyses with

tips of two kinds; most tips are racemose with about 12 lateral branches 3 μ long standing out from an axis 6 μ in diameter, other tips consist of 2 or 3 moniliform bodies — either kind of paraphysis may bear a cluster of lateral branches at some region more or less distant from the end; basidia 80–100×12 μ; spores hyaline, even, 18–21×12–13 μ.

Fructifications 1–2 mm. in diameter, becoming confluent into masses 2×1 cm.

On bark of dead *Ostrya virginica, Quercus alba, Q. macrocarpa, Salix,* hickory, etc. Canada to Alabama, westward to Missouri.

A. Oakesii resembles *A. amorphus* so closely in aspect that it was regarded by Fries in his 'Hymenomycetes Europaei' as a synonym of the latter species, from which Cooke demonstrated that it was clearly distinct by the paraphyses. It may be separated at sight by the hymenium of *A. Oakesii* not being convex, by the fructifications becoming very large by confluence, and by its occurrence on bark of frondose species.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 935a and b; Ell. & Ev., Fungi Col., 310; Kellerman, Ohio Fungi, 125; Rabenhorst, Fungi Eur., 3232; Ravenel, Fungi Car. **3**: 32, type distribution; Shear, N. Y. Fungi, 116.

Canada: Ontario, Carleton Place, *J. Macoun, 422;* London, *J. Dearness, 2647* (in Mo. Bot. Gard. Herb., 19516).

New England: *Oakes* (in Curtis Herb., 3102).

Vermont: Middlebury, *E. A. Burt.*

Rhode Island: *Olney* (in Curtis Herb., 1827).

New York: Alcove, *C. L. Shear,* in Shear, N. Y. Fungi, 116; Altamont, *E. A. Burt;* definite locality not given, *Sartwell* (in Curtis Herb., and in Mo. Bot. Gard. Herb., 4830); Buffalo, *G. W. Clinton* (in U. S. Dept. Agr. Herb.).

New Jersey: *Laning* (in Curtis Herb., and in Mo. Bot. Gard. Herb., 44128, 44129).

Pennsylvania: Bethlehem, *E. A. Rau,* in Ellis, N. Am. Fungi, 935a; Spruce Creek, *J. H. Faull,* Univ. of Toronto Herb., 366 (in Mo. Bot. Gard. Herb., 44915); State College, *C. R. Orton, 3* (in Mo. Bot. Gard. Herb., 44080); Trexlertown, *W.*

Herbst, 85; West Chester, *Everhart, Haines, Jefferis & Gray,* in Ellis, N. Am. Fungi, 935b.

West Virginia: Nuttallburg, *L. W. Nuttall,* in Ell. & Ev., Fungi Col., 310.

Alabama: *Peters,* in Ravenel, Fungi Car. **3**: 32, and (in Curtis Herb., 3868).

Ohio: Cincinnati, *A. P. Morgan* (in Lloyd Herb.); Columbus, *F. J. Tyler,* in Kellerman, Ohio Fungi, 125; Oberlin, *F. D. Kelsey* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 4831).

Michigan: Ann Arbor, *A. J. Pieters* (in U. S. Dept. Agr. Herb.).

Indiana: Crawfordsville, *D. Reddick, 11.*

Illinois: River Forest, *Miss A. O. Stucki, 11,* Univ. of Wisconsin Herb.

Wisconsin: Madison, four collections, as follows: collector not given (in Mo. Bot. Gard. Herb., 4832); *M. C. Jensen,* comm. by C. J. Humphrey (in Mo. Bot. Gard. Herb., 42942); *W. Trelease, 67* (in Mo. Bot. Gard. Herb., 4799); *Miss A. O. Stucki, 54,* Univ. of Wisconsin Herb.

Iowa: Decorah, *E. W. D. Holway* (in U. S. Dept. Agr. Herb.); Webster County, *O. M. Oleson, 1.*

Missouri: Columbia, *B. M. Duggar, 401;* Perryville, *C. H. Demetrio,* in Rabenhorst, Fungi Eur., 3232.

4. A. apiculatus Burt, n. sp.

Type: in Burt Herb.

Fructifications resupinate, effused, sometimes narrowly reflexed, coriaceous, pulverulent, drying pinkish buff, the reflexed margin tomentose, white, inrolled; in structure 600–800 μ thick, with the hyphae hyaline, even, thick-walled, $3\frac{1}{2}$–4 μ in diameter, not incrusted, not nodose-septate, loosely interwoven in the outer surface of the reflexed part, densely interwoven and longitudinally arranged in the middle region of that part and near the substratum, then curving outward and ascending to form the subhymenium and hymenium; all organs in subhymenium clothed with lateral prongs; paraphyses hyaline, some with outer end racemosely branched, 6–7 μ in diameter over branches, with the branches clothing the sides of the paraphyses for about 40–45 μ, and others with

outer end even and lateral prongs present at lower level of hymenium; basidia clavate, up to 100×12–15 μ, with 4 prominent sterigmata about 15 μ long; spores hyaline, unequilateral, apiculate, minutely echinulate, 20–25×12–15 μ.

Fig. 4. A. apiculatus. Flexuous paraphyses, *f*; paraphyses with aculeate prongs, *a*; basidium, *b*; and spores, *s*. ×870.

Fructifications 2½–10 cm. long, 6–15 mm. broad, with reflexed margin 1–1½ mm. broad.

On bark of pole of frondose wood on ground at 5,000 ft. altitude, and on dead limbs. Jamaica, Porto Rico, and Grenada. November.

Until microscopic examination of the sections was made, the collections were regarded as consisting of large specimens of *A. Oakesii,* which this species resembles in aspect but from which it differs in spore characters and in the absence of mo-

niliform paraphyses. The collections from Porto Rico and Grenada are probably rather immature, for many of their spores are even.

Specimens examined:

Jamaica: Cinchona, *F. S. Earle, 401,* N. Y. Bot. Gard., Plants of Jamaica, type.

Porto Rico: Vieques Island, Campo Cieto to Ensenada Hondo, *J. A. Shafer, 3048* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55453).

Grenada: Grand Etang, *R. Thaxter,* comm. by W. G. Farlow, 6.

5. A. candidus (Schw.) Burt, n. comb.

Thelephora candida Schweinitz, Naturforsch. Ges. Leipzig Schrift. **1**: 110. 1822; Fries, Elenchus Fung. **1**: 189. 1828.—*Thelephora candidissima* Schweinitz, Am. Phil. Soc. Trans. N. S. **4**: 167. 1832.—*Stereum candidum* (Schw.) Fries, Epicr. 552. 1838; Sacc. Syll. Fung. **6**: 585. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 200. 1890.

Type: in Herb. Schweinitz, Herb. Fries, and Curtis Herb.

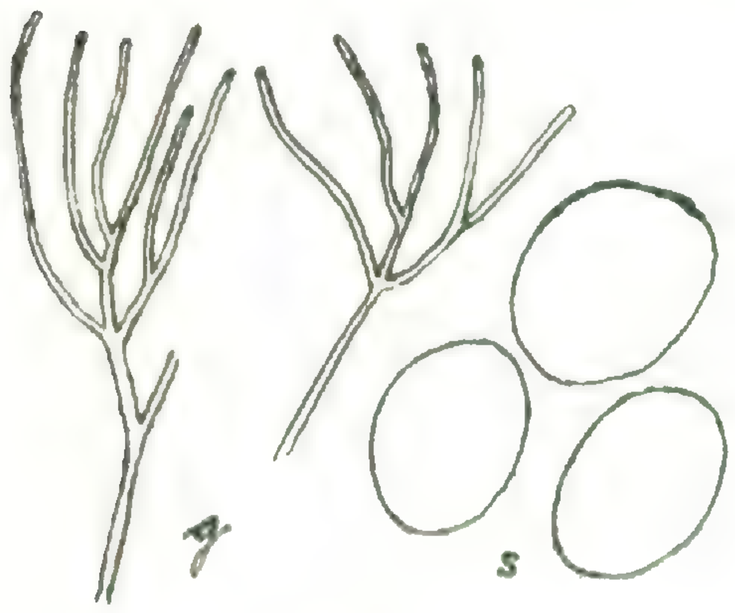

Fig. 5
A. candidus.
Granule-bearing paraphyses, *g*. after removal of the granular matter by HCl; spores of type, *s*. ×870.

Fructifications scattered, resupinate, adnate, at first convex and orbicular, soon expanded, flattened, following the inequalities of the bark, white, pruinose, the margin thick, entire, blackening underneath; in structure 800 μ thick, somewhat stratose, composed of densely arranged, suberect, interwoven, heavily incrusted, hyaline hyphae 2–3 μ in diameter under the incrustation, of which much of the matter is large, angular, crystalline grains; hymenium composed of clavate basidia 45–60×10–15 μ, and of thin-walled, hyaline, flexuous, incrusted, hyphal paraphyses with tips bushy, somewhat corymbosely branched, branches 2–3 μ in diameter under their incrustation, not moniliform and noteworthy, as are the hyphae, by the large amount of

crystalline matter attached to them—often by only a corner or small end of the crystal; spores hyaline, even, subglobose, 15–17×11–14 μ.

Fructifications usually 3–6 mm. in diameter, sometimes 1–2 cm.

On bark of trunks of living oaks, rarely on ash and maple. New York to Florida, westward to Missouri, in California, Mexico, and Jamaica. August to January.

This species resembles *A. disciformis* of Europe very closely in aspect but differs from it in being chalk-white, in having the margin blackening on the under side, in being thicker, somewhat zonate within, containing much more crystalline matter, and in having thinner-walled, slenderer, more hyphal-like, and more heavily incrusted paraphyses which are not at all moniliform at the tips. The spores may prove minutely rough-walled; winter collections of this species are desirable.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 1206; Ell. & Ev., N. Am. Fungi, 3208, under the name *Stereum acerinum;* Ell. & Ev., Fungi Col., 605; Ravenel, Fungi Am., 120; Ravenel, Fungi Car. **1**: 32.

New York: Buffalo, *G. W. Clinton.*

Pennsylvania: Bethlehem, *E. A. Rau,* in Ellis, N. Am. Fungi, 1206.

Maryland: Takoma Park, *C. L. Shear, 1104.*

West Virginia: Nuttallburg, *L. W. Nuttall,* two collections, in Ell. & Ev., N. Am. Fungi, 3208, and in Ell. & Ev., Fungi Col., 605.

North Carolina: Salem, *Schweinitz* (in Herb. Fries and in Curtis Herb.); Blowing Rock, *G. F. Atkinson, 4193, 4320;* Chapel Hill, *H. R. Totten,* comm. by W. C. Coker, Univ. of N. Car. Herb., 1377a (in Mo. Bot. Gard. Herb., 9057).

South Carolina: Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 120; locality not stated, *H. W. Ravenel,* Fungi Car. **1**: 32.

Florida: Sands Key, *R. A. Harper, 8* (in Mo. Bot. Gard. Herb., 54526).

Cuba: *C. Wright* (in Curtis Herb.); Alto Cedro, *Earle & Murrill, 495;* Herradura, *Earle & Murrill, 156.*

Porto Rico: Bayamon, *J. A. Stevenson, 6758* (in Mo. Bot. Gard. Herb., 55058).

Trinidad: Verdant Vale, *R. Thaxter,* comm. by W. G. Farlow, 23.

Mexico: probably portion of type (from E. Fries in Kew Herb.); Orizaba, *W. A. & Edna L. Murrill, 778* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 54608).

Nicaragua: *C. Wright,* U. S. Northern Pacific Expl. Exp., under the name *Corticium sulphureum* (in Curtis Herb.).

7. **A. seriatus** (Berk. & Curtis) Burt, n. comb.

Stereum seriatum Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 332. 1868; Sacc. Syll. Fung. **6**: 581. 1888.

Type: in Kew Herb. and Curtis Herb.

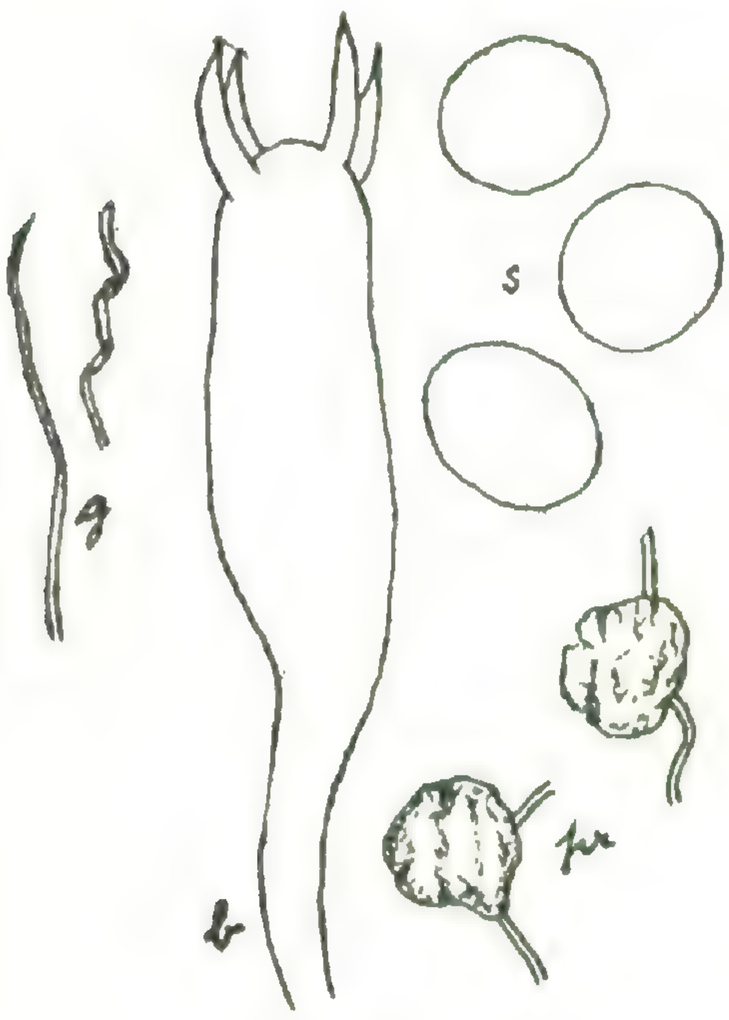

Fig. 7
A. seriatus.
Flexuous and spirally twisted paraphyses, *g*, after removal of the granular matter by HCl; basidium, *b;* spores, *s;* proteid bodies, *pr.* ×870.

Fructifications scattered, resupinate, adnate, orbicular or oblong, sometimes confluent, convex, white, pruinose, becoming between pinkish buff and deep olive-buff when old, the margin adnate, neither free nor elevated; in structure 600 μ thick, somewhat stratose, composed of suberect hyphae heavily incrusted with fine granules and bearing such granules laterally in adhering masses; hymenium composed of basidia and granule-incrusted hyphal filaments, or paraphyses, which are filiform, thin-walled, flexuous or spirally twisted, 2 μ in diameter under the incrustation; basidia 40–50×12 μ, with 4 sterigmata, each about 9×3 μ; spores hyaline, even, 11–18×9½–13 μ; globose organs of proteid reaction, 6–15 μ in diameter, with shriveled

crystalline matter attached to them—often by only a corner or small end of the crystal; spores hyaline, even, subglobose, 15–17×11–14 μ.

Fructifications usually 3–6 mm. in diameter, sometimes 1–2 cm.

On bark of trunks of living oaks, rarely on ash and maple. New York to Florida, westward to Missouri, in California, Mexico, and Jamaica. August to January.

This species resembles *A. disciformis* of Europe very closely in aspect but differs from it in being chalk-white, in having the margin blackening on the under side, in being thicker, somewhat zonate within, containing much more crystalline matter, and in having thinner-walled, slenderer, more hyphal-like, and more heavily incrusted paraphyses which are not at all moniliform at the tips. The spores may prove minutely rough-walled; winter collections of this species are desirable.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 1206; Ell. & Ev., N. Am. Fungi, 3208, under the name *Stereum acerinum;* Ell. & Ev., Fungi Col., 605; Ravenel, Fungi Am., 120; Ravenel, Fungi Car. 1 : 32.

New York: Buffalo, *G. W. Clinton.*

Pennsylvania: Bethlehem, *E. A. Rau,* in Ellis, N. Am. Fungi, 1206.

Maryland: Takoma Park, *C. L. Shear, 1104.*

West Virginia: Nuttallburg, *L. W. Nuttall,* two collections, in Ell. & Ev., N. Am. Fungi, 3208, and in Ell. & Ev., Fungi Col., 605.

North Carolina: Salem, *Schweinitz* (in Herb. Fries and in Curtis Herb.); Blowing Rock, *G. F. Atkinson, 4193, 4320;* Chapel Hill, *H. R. Totten,* comm. by W. C. Coker, Univ. of N. Car. Herb., 1377a (in Mo. Bot. Gard. Herb., 9057).

South Carolina: Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 120; locality not stated, *H. W. Ravenel,* Fungi Car. 1 : 32.

Florida: Sands Key, *R. A. Harper, 8* (in Mo. Bot. Gard. Herb., 54526).

Alabama: Montgomery, *R. P. Burke, 121* (in Mo. Bot. Gard. Herb., 21223).
Ohio: Lancaster, *W. A. Kellerman, 284.*
Missouri: Creve Coeur, *L. O. Overholts, 669* (in Mo. Bot. Gard. Herb., 4801); St. Louis, *E. A. Burt* (in Mo. Bot. Gard. Herb., 44044).
California: Muir Woods, *W. A. Murrill, 1155,* N. Y. Bot. Gard. (in Mo. Bot. Gard. Herb., 55453).
Mexico: Oaxaca, *E. W. D. Holway.*
Jamaica: Cinchona, *W. A. & Edna L. Murrill, 565,* N. Y. Bot. Gard., Fungi of Jamaica.

6. A. strumosus (Fries) Burt, n. comb.

Stereum strumosum Fries (Nov. Symb. Myc. 95), R. Soc. Sci. Upsal. Actis III. **1**: 111. 1851; Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 333. 1868; Sacc. Syll. Fung. **6**: 586. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 203. 1890.—*Stereum (?) vitellinum* Leveille in Triana & Planchon, Prod. Fl. Novo-Granat. Crypt. 157. 1863–1867.—*Stereum Mancianum* Sacc. & Cub. in Sacc. Syll. Fung. **6**: 583. 1888.—*Aleurodiscus Mancianus* (Sacc. & Cub.) Patouillard, Soc. Myc. Fr. Bul. **16**: 180. 1901.

Type: specimen from Fries in Kew Herb.

Fructifications resupinate, adnate, orbicular, scattered, sometimes confluent and effused, drying between antimony-yellow and yellow-ocher at the surface and white within, the margin rather thick, sometimes free, entire; in structure 300–500 μ thick, rarely strata, composed of granule-incrusted, thin-walled, hyaline hyphae, some of which are suberect, 2 μ in diameter under incrustation, barely visible except by their load of incrusting grains, interwoven, and apparently branches from the

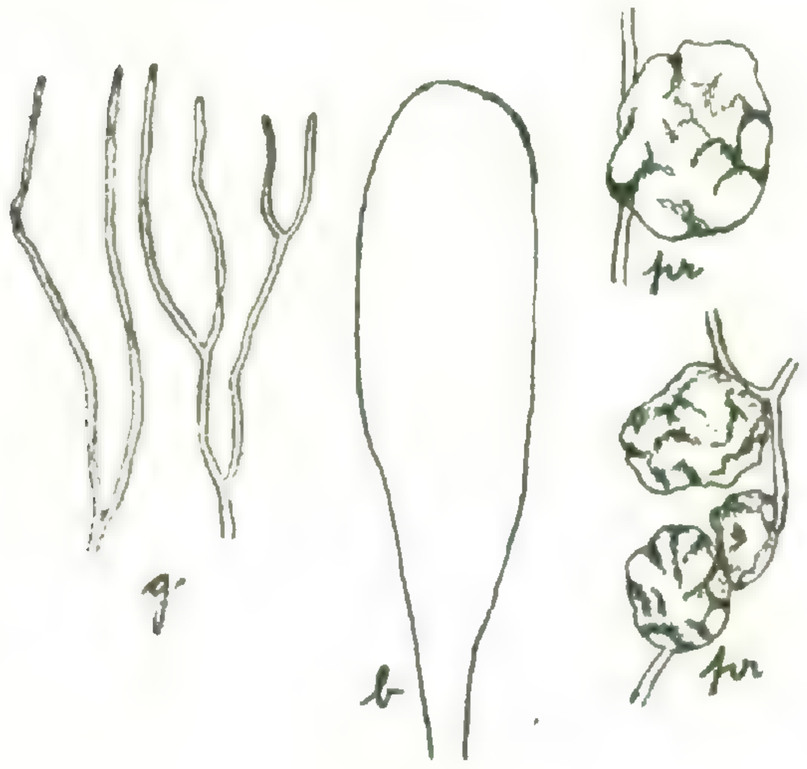

Fig. 6
A. strumosus.
Granule-bearing paraphyses, *g*, after removal of the granular matter by HCl; immature basidium, *b*; proteid bodies, *pr*. ×870.

coarser hyphae; globose organs of proteid reaction, 6–15 μ in diameter, with shriveled or wrinkled surface, are scattered throughout the fructification; hymenium composed of granule-incrusted hyphal systems and of presumable basidia buried among the incrusted hyphae; such basidia-like bodies clavate, 60–100×15–20 μ, yellow in KHO preparations, simple, none seen bearing sterigmata; detached spores hyaline, even, 18–27×12–21 μ.

Fructifications 2–5 mm. in diameter, becoming up to 3 cm. long by confluence.

On bark of frondose trees. South Carolina to Louisiana, West Indies, and Mexico to Colombia.

This species may be recognized by its pulverulent, egg-yellow, orbicular fructifications which are white within and contain so much granular matter as to render other details of internal structure obscure and difficult of determination. This granular matter holds together so as to show that it is incrusting matter upon very tenuous, nonstaining hyphal filaments. While I do not doubt that the large, yellow, clavate organs near the hymenial surface but buried in the granular matter are immature basidia, still I have not demonstrated their sterigmata in the preparations of any of the collections which have been examined up to the present. The globose organs show distinctly in stained preparations which have been heated in dilute HCl to free them of the crystalline matter.

Specimens examined:

Exsiccati: Ravenel, Fungi Car. **3**: 28, under the herbarium name *Corticium citrinum* Berk. & Rav. but not of Fries.

South Carolina: in Ravenel, Fungi Car. **3**: 28; Black Oak, *H. W. Ravenel, 1397,* under the name *Corticium citrinum* (in Curtis Herb.).

Florida: Daytona, *R. Thaxter, 52, 62* (in Farlow Herb. and in Mo. Bot. Gard. Herb., 43942 and 43944); Ocala, *R. Thaxter, 58* (in Farlow Herb., and in Mo. Bot. Gard. Herb., 43943).

Louisiana: St. Martinville, *A. B. Langlois, 1953.*

Jamaica: Morce's Gap, *W. A. & Edna L. Murrill, 714,* N. Y. Bot. Gard., Fungi of Jamaica.

Cuba: *C. Wright* (in Curtis Herb.); Alto Cedro, *Earle & Murrill, 495;* Herradura, *Earle & Murrill, 156.*

Porto Rico: Bayamon, *J. A. Stevenson, 6758* (in Mo. Bot. Gard. Herb., 55058).

Trinidad: Verdant Vale, *R. Thaxter,* comm. by W. G. Farlow, 23.

Mexico: probably portion of type (from E. Fries in Kew Herb.); Orizaba, *W. A. & Edna L. Murrill, 778* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 54608).

Nicaragua: *C. Wright,* U. S. Northern Pacific Expl. Exp., under the name *Corticium sulphureum* (in Curtis Herb.).

7. **A. seriatus** (Berk. & Curtis) Burt, n. comb.

Stereum seriatum Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 332. 1868; Sacc. Syll. Fung. **6**: 581. 1888.

Type: in Kew Herb. and Curtis Herb.

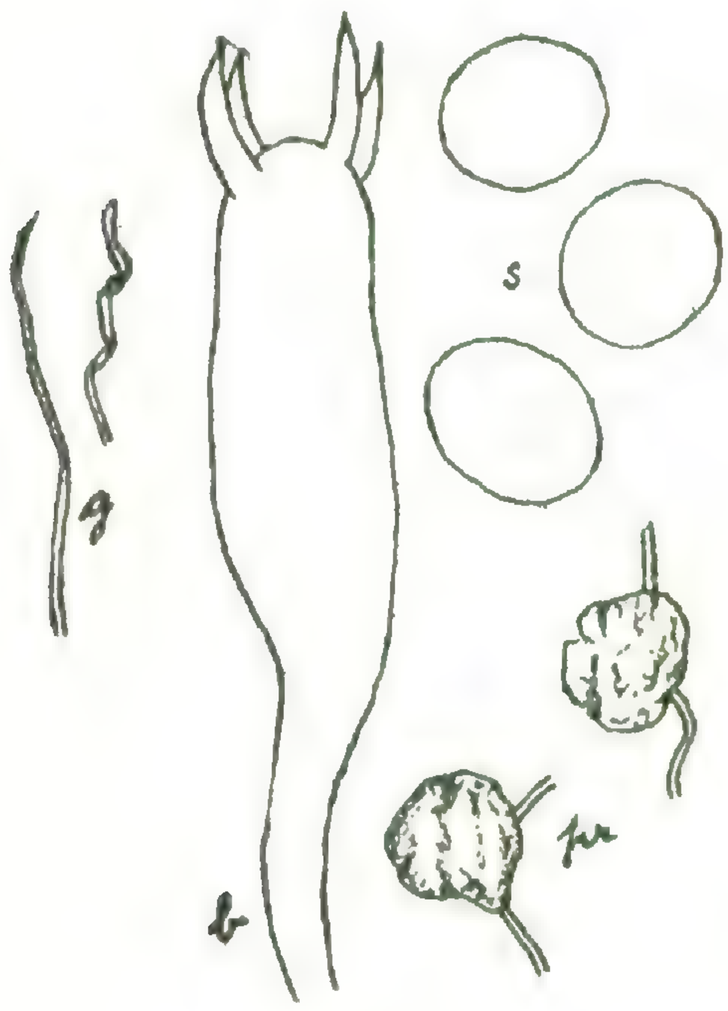

Fig. 7
A. seriatus.
Flexuous and spirally twisted paraphyses, *g*, after removal of the granular matter by HCl; basidium, *b;* spores, *s;* proteid bodies, *pr.* ×870.

Fructifications scattered, resupinate, adnate, orbicular or oblong, sometimes confluent, convex, white, pruinose, becoming between pinkish buff and deep olive-buff when old, the margin adnate, neither free nor elevated; in structure 600 μ thick, somewhat stratose, composed of suberect hyphae heavily incrusted with fine granules and bearing such granules laterally in adhering masses; hymenium composed of basidia and granule-incrusted hyphal filaments, or paraphyses, which are filiform, thin-walled, flexuous or spirally twisted, 2 μ in diameter under the incrustation; basidia 40–50×12 μ, with 4 sterigmata, each about 9×3 μ; spores hyaline, even, 11–18×9½–13 μ; globose organs of proteid reaction, 6–15 μ in diameter, with shriveled

or wrinkled surface, are scattered throughout the fructification.

Fructifications of type 2–6×2–4 mm.—15 fructifications on an area $4\frac{1}{2}\times2$ cm.

On bark of frondose trees. Jamaica and Cuba. October to January.

In the original description *A. seriatus* was regarded as allied to *A. candidus*, but it is much closer to *A. nivosus*, differing with the latter from *A. candidus* by convex surface of fructification, by margin not at all free nor reflexed, and by incrusting matter of hyphae not occurring in large crystalline grains. All the collections which I have referred to *A. seriatus* have been scanty and bearing few spores; this species seems distinct from *A. nivosus* by the absence of clavate or cylindric gloeocystidia and by having the paraphyses spirally twisted and usually distinct from their tips to about the base of the basidia, and by having characteristic globose organs scattered throughout the sections, such as occur in *Corticium pallidum* Bres. and have been regarded and figured by v. Höhnel & Litschauer as gloeocystidia.[1]

Specimens examined:

Jamaica: Cinchona, *W. A. & Edna L. Murrill, 565*, N. Y. Bot. Gard., Fungi of Jamaica; near Hope Gardens, *W. A. Murrill, 20*, N. Y. Bot. Gard., Fungi of Jamaica; Troy and Tyre, *W. A. Murrill & W. Harris, 1106*, N. Y. Bot. Gard., Fungi of Jamaica.

Cuba: *C. Wright, 283*, type (in Curtis Herb.); Ceballos, *C. J. Humphrey, 2847* (in Mo. Bot. Gard. Herb., 20202).

8. **A. nivosus** (Berk. & Curtis) v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116**: 808. *pl. 4. f. 2.* 1907.

Stereum acerinum var. *nivosum* Berk. & Curtis, Grevillea **1**: 165. 1873 (lacks description but refers to specimen in Ravenel, Fungi Car. **2**: 37); Sacc. Syll. Fung. **6**: 588. 1888.

Type: type distribution in Ravenel, Fungi Car. **2**: 37, under the name *Stereum acerinum*.

Fructifications small, resupinate, adnate, circular or oblong, convex at first, becoming plane, white, the margin thick, de-

[1] K. Akad. Wiss. Wien Sitzungsber. **116**: 838. *text f. 20*. 1907.

terminate, adnate; in structure 200–250 μ thick, not stratose, composed of erect, interwoven, thin-walled, hyaline hyphae about 2 μ in diameter, bearing a large amount of incrusting granular matter; hymenium consisting of basidia, gloeocystidia, paraphyses, and many incrusted hyphae; gloeocystidia clavate, hyaline, even, 18–30×9 μ; paraphyses about 2–3 μ in diameter under the incrustation, cylindric, flexuous, more or less irregular in form, somewhat corymbosely branched at surface of hymenium and with branches loaded with crystalline matter; basidia clavate, 40–60×12–16 μ, only rarely found, with 4 divergent sterigmata; spores hyaline, even, 15–20×12–16 μ.

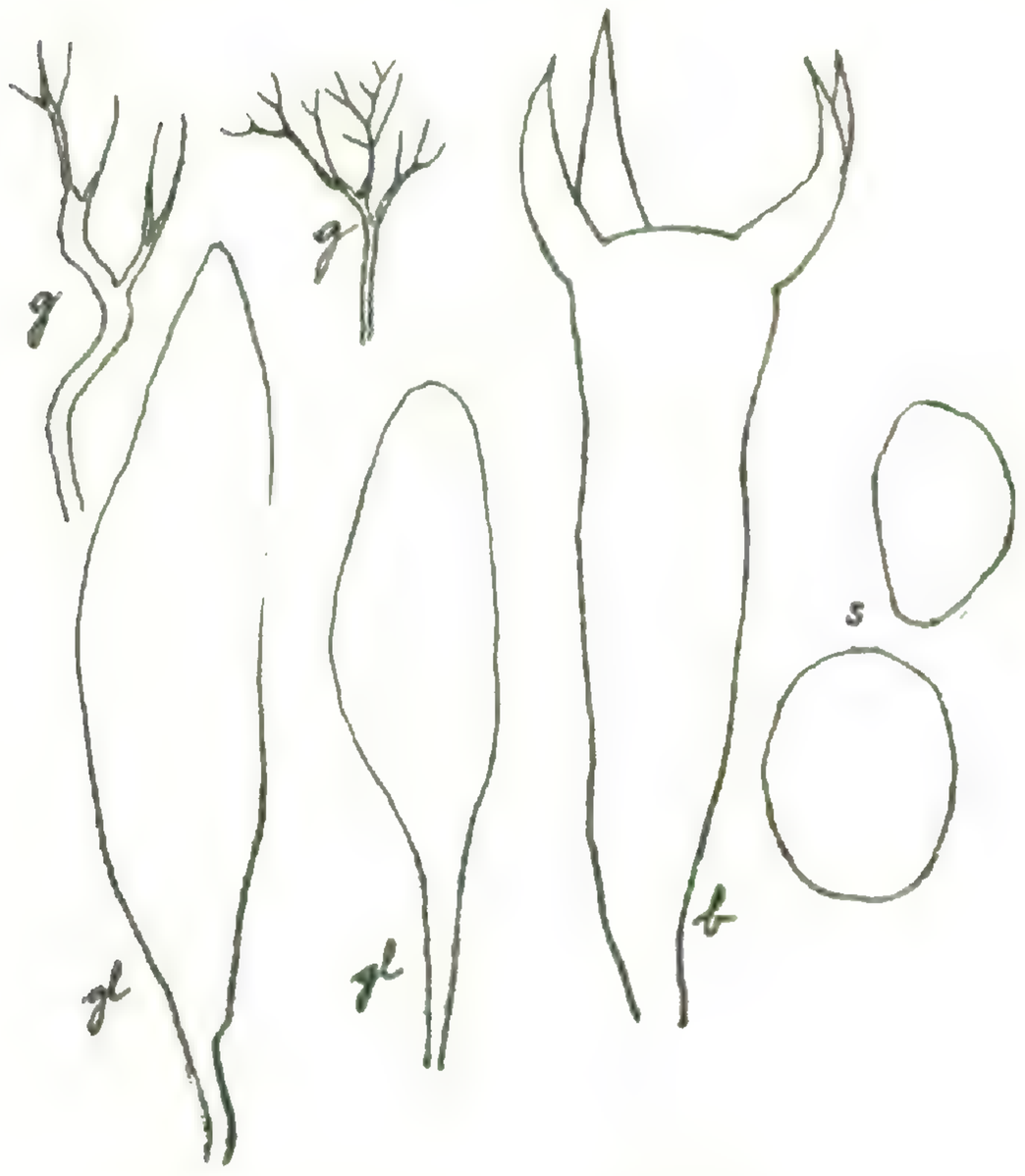

Fig. 8. A. nivosus. Granule-bearing paraphyses, *g*, after removal of the granular matter by HCl; gloeocystidia, *gl;* basidium, *b;* spores, *s.* ×870.

Fructifications 3–30 mm. long, about 2–6 mm. broad.

On bark of living trees, common on *Juniperus virginiana*, occurs also on *Juniperus occidentalis* and *Chamaecyparis.* Vermont to Texas, westward to Oregon, and in Jamaica. Throughout the year.

A. nivosus is intermediate between *A. candidus* and *A. acerinus,* differing from the former by thinner and more elongated fructifications which are not at all stratose within, by incrusting matter not in the form of large, angular, crystalline grains, by margin with no tendency to be free nor blackening on under side, and by the common occurrence of the fructification on bark of living red cedar. It differs from *A. acerinus* by presence of gloeocystidia, which show best near

the substratum, by the corymbosely branched paraphyses, and by the larger spores. Von Höhnel's figures and description of *A. nivosus* are incorrect in regard to spores and paraphyses.

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 2880; Ellis, N. Am. Fungi, 326; Ell. & Ev., Fungi Col., 1207; Rabenhorst, Fungi Eur., 3647a and b; Ravenel, Fungi Am., 119; Ravenel, Fungi Car. **2**: 37, type distribution; Shear, N. Y. Fungi, 52; de Thümen, Myc. Univ., 711.

Vermont: Middlebury, *E. A. Burt.*

Massachusetts: Cambridge, *E. A. Burt;* Medford, *W. Trelease, 80* (in Mo. Bot. Gard. Herb., 5059); Waltham, *E. A. Burt;* Waverly, *W. A. Setchell.*

Connecticut: Norwich, *W. A. Setchell.*

New York: Alcove, *C. L. Shear,* in Shear, N. Y. Fungi, 52; Orient, *R. Latham, 189* (in Mo. Bot. Gard. Herb., 44228).

New Jersey: Newfield, *J. B. Ellis, 1518,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb.), in Ellis, N. Am. Fungi, 326, and in Ell. & Ev., Fungi Col., 1207.

Virginia: Woodstock, *C. L. Shear, 1194.*

South Carolina: *H. W. Ravenel,* in Ravenel, Fungi Car. **2**: 37; Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 119, and in de Thümen, Myc. Univ., 711; Clemson College, *P. H. Rolfs, 1618.*

Florida: Gainesville, *N. L. T. Nelson, 95* (in Lloyd Herb.).

Alabama: Spring Hill, *C. Mohr,* comm. by H. von Schrenk (in Mo. Bot. Gard. Herb., 43020).

Texas: Austin, *W. H. Long, 534.*

Ohio: Oxford, *L. O. Overholts, 662* (in Mo. Bot. Gard. Herb., 55445).

Kentucky: Mammoth Cave, *C. G. Lloyd, 2560.*

Missouri: Perryville, *C. H. Demetrio,* in Rabenhorst, Fungi Eur., 3647b.

Arkansas: Batesville, *E. Bartholomew,* in Bartholomew, Fungi Col., 2880.

Kansas: Manhattan, *W. A. Kellerman,* in Rabenhorst, Fungi Eur., 3647a, and (in U. S. Dept. Agr. Herb.).

Oregon: White Pine, *J. R. Weir, 398* (in Mo. Bot. Gard. Herb., 16266).

Jamaica: Cinchona, *F. S. Earle, 417,* N. Y. Bot. Gard., Plants of Jamaica.

9. **A. acerinus** (Pers.) v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116**: 804. *pl. 2. f. 6.* 1907; Bourd. & Galz. Soc. Myc. Fr. Bul. **28**: 352. 1913.

Corticium acerinum Persoon, Obs. Myc. **1**: 37. 1796; Romell, Bot. Not. **1895**: 71. 1895.—*Thelephora acerina* Persoon, Syn. Fung. 581. 1801; Myc. Eur. **1**: 152. 1822; Fries, Syst. Myc. **1**: 453. 1821; Hym. Eur. 648. 1874.—*Stereum acerinum* (Pers.) Fries, Epicr. 554. 1838; Sacc. Syll. Fung. **6**: 587. 1888.

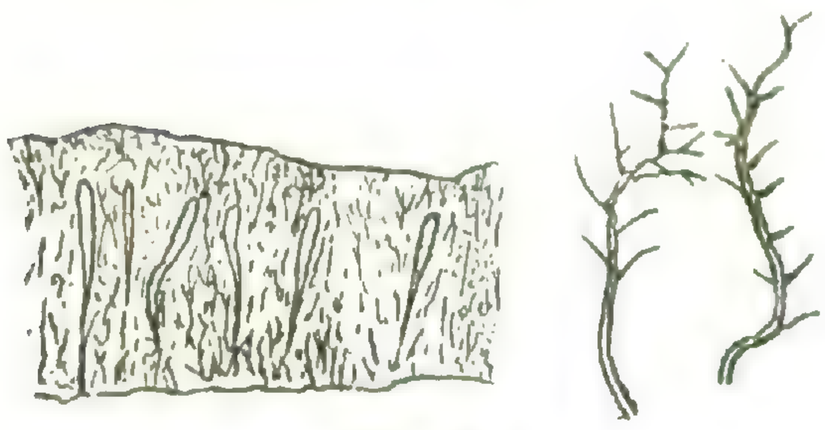

Fig. 9

A. acerinus.

Vertical section of fructification showing scattered immature basidia and absence of gloeocystidia. ×92; granule-bearing paraphyses after removal of the granular matter by HCl. ×870.

Fructifications scattered, resupinate, crustaceous, adnate, thin, even, white, the margin abrupt; in structure 45–80 μ thick, consisting of densely arranged, hyaline, thin-walled, suberect hyphae about 2–3 μ in diameter, heavily incrusted, rising between the basidia to the surface and terminating in a racemose manner with short, slender branches, loaded with crystalline matter; basidia clavate, 30–45×6 μ; spores hyaline, even, 10–12×6–7 μ.

Fructifications about 3 mm. in diameter, rarely elongated up to 10 mm. long, 3 mm. broad.

On bark of trunks of living maple, oak, etc. Vermont to Texas, westward to Missouri, and in Cuba and Mexico. Throughout the year.

This species may be recognized by its occurrence in scattered, small, white, circular or oblong fructifications on the bark of trunks of living white oak, maple, elm, ash, etc. The smaller spores, racemose paraphyses, and absence of gloeocystidia are structural characters separating the species from *A. seriatus* and *A. nivosus.* Our American collections are

frequently merely a thin mycelium containing a great deal of incrusting matter and not showing basidia and spores.

Specimens examined:

Exsiccati: Berkeley, Brit. Fungi, 65; Fl. Exs. Austro-Hungarica, 3152, under the name *Corticium calceum;* Romell, Fungi Scand. Exs., 125, 127.

Sweden: Stockholm, *L. Romell,* in Romell, Fungi Scand. Exs., 125, 127.

Austria-Hungary: Peggau, *Wettstein,* in Fl. Exs. Austro-Hungarica, 3152; Trento, *G. Bresadola.*

England: *M. J. Berkeley,* in Berkeley, Brit. Fungi, 65.

New Hampshire: Chocorua, *W. G. Farlow;* Jaffrey, *W. G. Farlow.*

Vermont: Grand View Mt., *E. A. Burt;* Middlebury, *E. A. Burt.*

New York: *G. F. Atkinson, 7987;* Alcove, *C. L. Shear, 1302, 1305;* Buffalo, *G. W. Clinton,* comm. by U. S. Dept. Agr. Herb.; East Galway, *E. A. Burt;* Ithaca, *L. A. Zimm, 90* (in Mo. Bot. Gard. Herb., 9061), *G. F. Atkinson, 22964;* Orient, *R. Latham, 59* (in Mo. Bot. Gard. Herb., 44234); Vaughns, *S. H. Burnham, 11* (in Mo. Bot. Gard. Herb., 44106).

Pennsylvania: State College, *L. O. Overholts & A. S. Rhoads,* comm. by L. O. Overholts, 3143 (in Mo. Bot. Gard. Herb., 5720).

Maryland: Plummers Island, *C. L. Shear, 1183;* Takoma Park, *C. L. Shear, 1070.*

North Carolina: Chapel Hill, *H. R. Totten,* comm. by W. C. Coker, Univ. of N. Car. Herb., 2020 (in Mo. Bot. Gard. Herb., 8871).

South Carolina: Clemson College, *P. H. Rolfs, 1824.*

Florida: Cocoanut Grove, *R. Thaxter, 89* (in Farlow Herb., and in Mo. Bot. Gard. Herb., 43913); Palm Beach, *R. Thaxter, 9* (in Farlow Herb., and in Mo. Bot. Gard. Herb., 43925).

Alabama: Montgomery County, *R. P. Burke, 64* (in Mo. Bot. Gard. Herb., 15119).

Mississippi: Hattiesburg, *C. J. Humphrey, 5442.*

Louisiana: Baton Rouge, *Edgerton & Humphrey*, comm. by C. J. Humphrey, 5600.
Texas: Houston, *H. W. Ravenel, 269*, comm. by U. S. Dept. Agr. Herb.
Missouri: Creve Coeur Lake, *L. O. Overholts, 3168* (in Mo. Bot. Gard. Herb., 5707).
Mexico: Jalapa, *W. A. & Edna L. Murrill, 331* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54502); Orizaba, *W. A. & Edna L. Murrill, 776* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54613).

10. **A. botryosus** Burt, n. sp.

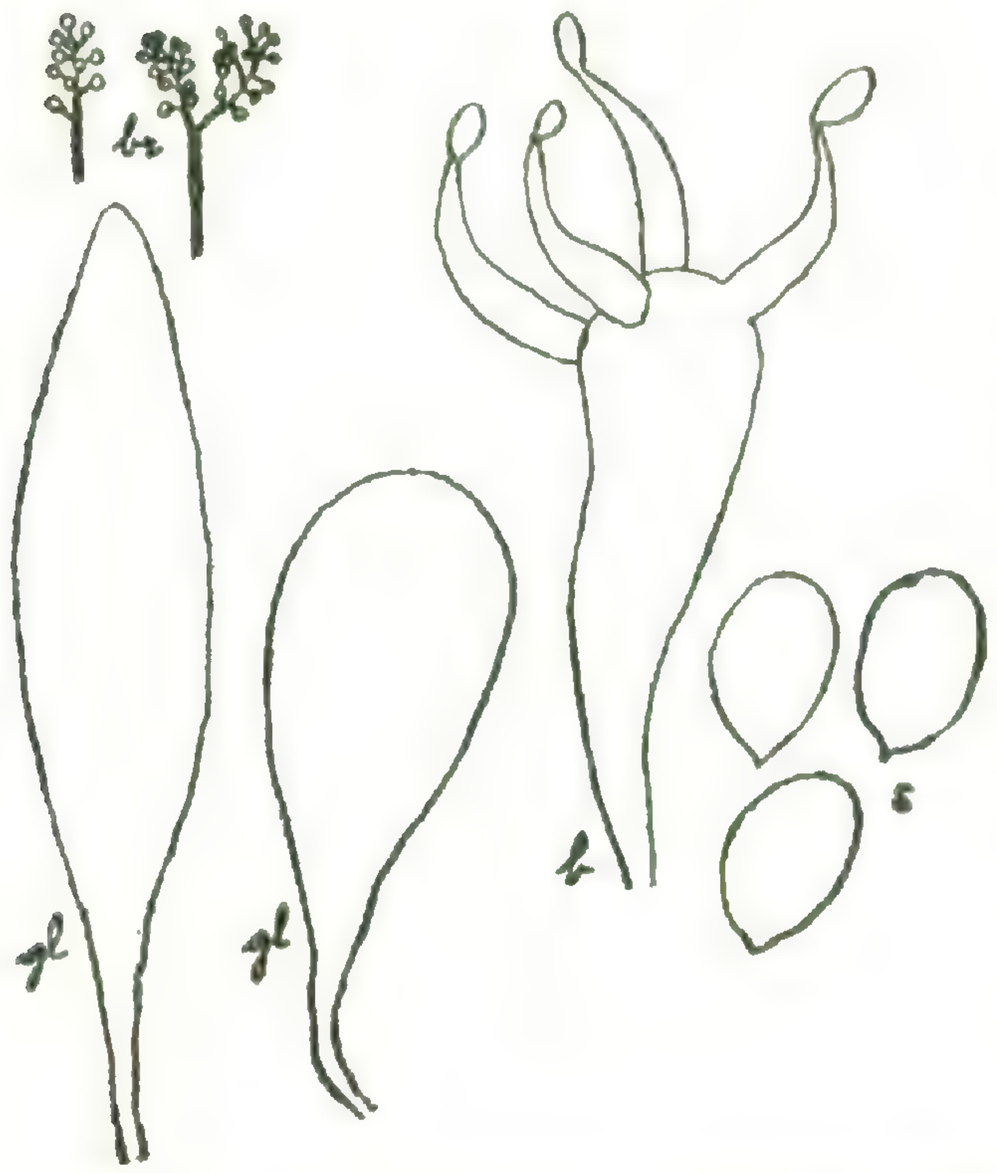

Fig. 10. A. botryosus. Racemose paraphyses, *br;* gloeocystidia, *gl;* basidium, *b;* and spores, *s.* ×870.

Type: in Burt Herb.

Fructifications resupinate, effused, adnate, scattered, becoming confluent, at first white and very thin, finally thicker, cracking in drying and sometimes pale olive-buff, the margin thinning out, pruinose; in structure 150–200 μ thick, composed of erect, crowded hyphae, gloeocystidia, basidia, and short, erect, bottle-brush branches similar to the paraphyses; hyphae hyaline, even, thin-walled, with irregular outlines, 2 μ in diameter; gloeocystidia usually near the substratum, cylindric, flexuous, 80×6–7 μ, or sometimes clavate, 45×12–16 μ; basidia clavate, about 40×12 μ, with 4 divergent sterigmata 15 μ long, 3–4 μ in diameter at base; spores hyaline, even, 13–15×9–11 μ; paraphyses with tips racemose and the short lateral prongs minutely globose at the end; racemose portions 10–15×3–4½ μ over branches; similar racemose

branches are more or less abundant through the whole of the fructification.

Fructifications at first 2–3×1–1½ mm., becoming confluent over areas 3–8 cm. × 5–10 mm.

On dead stems of *Rubus* and *Vitis*. Massachusetts, Maryland, and Mexico. November to April. Rare.

This species closely resembles in aspect and general details of structure an authentic specimen of *A. cerussatus* in my herbarium, but differs from the latter species chiefly in having bottle-brush organs not confined to the hymenial surface but distributed through the whole thickness of the fructification; other less important differences are slightly larger spores and basidia and much larger sterigmata, and less widely effused fructifications. *A. botryosus* resembles *A. nivosus* somewhat in aspect but differs from it by having bottle-brush paraphyses. *Thelephora albidocarnea* Schw., originally collected on *Vitis* and to which I have referred in my herbarium two scanty collections on *Vitis*, has aspect very similar to *A. botryosus*, but sectional preparations of *T. albidocarnea* do not show gloeocystidia and apparently have much smaller basidia and spores. *T. albidocarnea* should receive consideration when collections resembling *A. botryosus* are made on *Vitis*.

Specimens examined:

Massachusetts: Sharon, *A. P. D. Piguet*, two collections (in Farlow Herb., and in Mo. Bot. Gard. Herb., 54774, 55277).

Maryland: Takoma Park, *C. L. Shear, 1025*, type, *1127*, and *1357*.

Mexico: Jalapa, *W. A. & Edna L. Murrill, 320* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54497).

11. **A. cremeus** Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications resupinate, effused, adnate, convex at first, then confluent and plane, drying cracked and cream-buff, the margin thick and entire; in structure 600–800 μ thick, containing much crystalline matter arranged in layers, with hyphae suberect, interwoven; hymenium composed of clavate basidia, bottle-brush paraphyses 6–7 μ in diameter, and of

clavate, even-walled paraphyses 6 μ in diameter with the tip more or less constricted to form a single moniliform body; gloeocystidia few, inconspicuous, clavate or cylindric, flexuous, 30–45×5–6 μ; no basidia with sterigmata observed; probable spores imbedded in hymenial surface, spherical, even, hyaline, 9 μ in diameter.

Fig. 11
A. cremeus.
Bottle-brush paraphysis, *br;* other paraphyses, *m;* gloeocystidium, *gl.* ×870.

Fructifications at first 2–5 mm. long, about 1–2½ mm. broad, becoming confluent into masses 5 cm. long, 1–1½ cm. broad.

On decorticated dead wood of *Quercus Gambelii.* New Mexico. September.

A. cremeus belongs in the group with *A. botryosus, A. cerussatus,* and *A. penicillatus* but is much thicker than these and differs in its other characters as enumerated. *A. croceus* Pat., of Ecuador, differs by reflexed margin, larger and ovoid spores, and absence of paraphyses with moniliform tips.

Specimens examined:

New Mexico: Cienega Canyon, *W. H. Long, 21528,* type (in Mo. Bot. Gard. Herb., 55128).

12. A. tenuis Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and in Lloyd Herb.

Fructifications resupinate, effused, very thin, white, pruinose, the margin entire; in structure 60–90 μ thick, composed of two kinds of densely arranged, erect organs which start from the substratum and extend to surface of hymenium — (1)

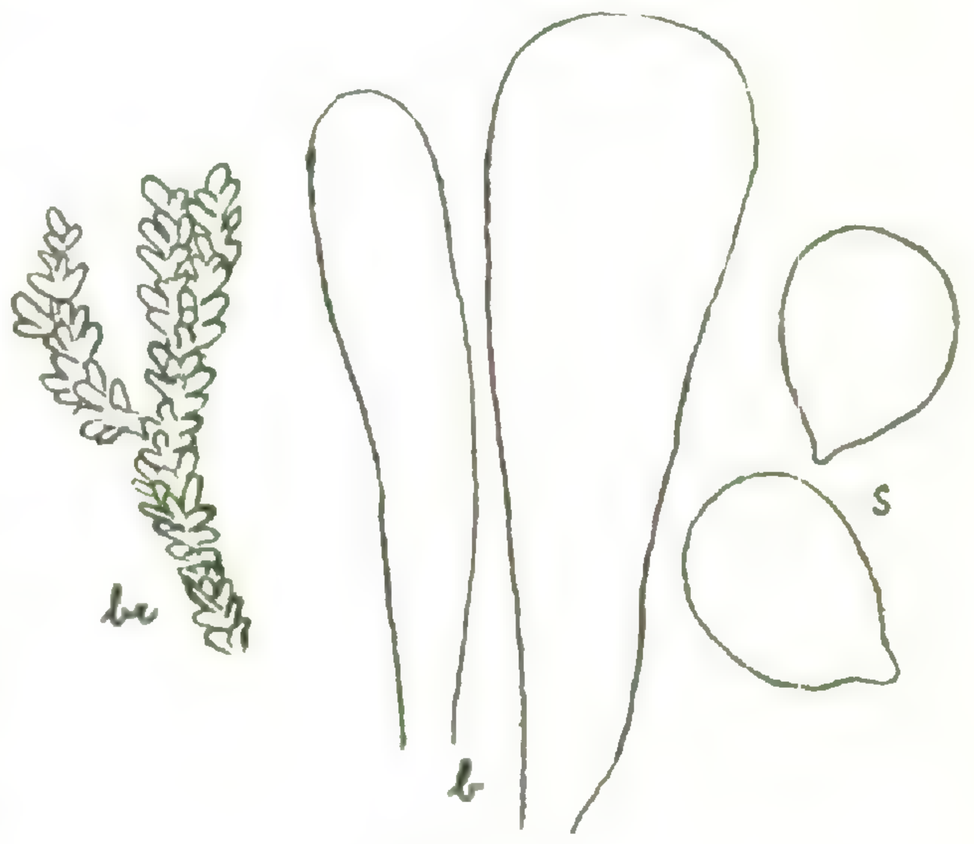

Fig. 12
A. tenuis.
Paraphyses before treatment with KHO, *br;* immature basidia, *b;* and spores, *s.* ×870.

bushy, branched, cylindric, bottle-brush paraphyses about 4½ μ in diameter over prongs, uniformly clothed for their length with such lateral outgrowths which are disorganized and dissolved by KHO solution but not affected by dilute hydrochloric acid nor lactic acid, and (2) deeply staining, cylindric organs usually 4½–5 μ in diameter, sometimes clavate and then up to 9 μ in diameter; spores hyaline, even, 12–15× 9–12 μ.

Fructifications 1–1½ cm. broad, 7 cm. long, and broken at both ends.

On small dead twigs of frondose wood. Cuba. March.

This species may be recognized at the time of collection by its snow-white color, very thin fructification which resembles a thin *Corticium,* and occurrence along one side of small dead twigs of frondose species; the small, even spores and bushy paraphyses whose bottle-brush outer surface is disorganized by treatment of preparation with KHO solution afford good distinctive microscopical characters. Mature basidia, when found, may show that this species belongs in *Sebacina* rather than in *Aleurodiscus*—a view which seems the more probable because of the peculiar effect of KHO solution upon the paraphyses.

Specimens examined:

Cuba: *C. G. Lloyd, 421, 422,* type (in Mo. Bot. Gard. Herb., 55178, 55179 respectively).

13. A. penicillatus Burt, n. sp.

Type: in Burt Herb.

Fructification resupinate, effused, adnate, cracking in drying, pale ochraceous-buff at first, becoming between light buff and pinkish buff in the herbarium, the margin determinate; in structure about 200 μ thick, composed of loosely interwoven, suberect, hyaline hyphae 3 μ in diameter, occasionally nodose-septate, not incrusted; hymenium composed of large, clavate basidia about 75×18 μ, with large sterigmata, and of flexuous paraphyses about 6 μ in diameter, of several forms, of which the most noteworthy have about the obtuse apex a cluster of about 12 acicular branches, each about 4 μ long; spores hya-

line, minutely echinulate, subglobose, 15–18 μ, or rarely 20 μ, in diameter.

Fructifications at first about 2–3 mm. in diameter, then laterally confluent into patches up to 10 cm. long and 2 cm. broad.

On stem and twigs of dead standing seedling of *Pseudotsuga taxifolia* and on limbs of *Tsuga heterophylla* on the ground. Idaho, Washington, and Oregon. September and October. Rare.

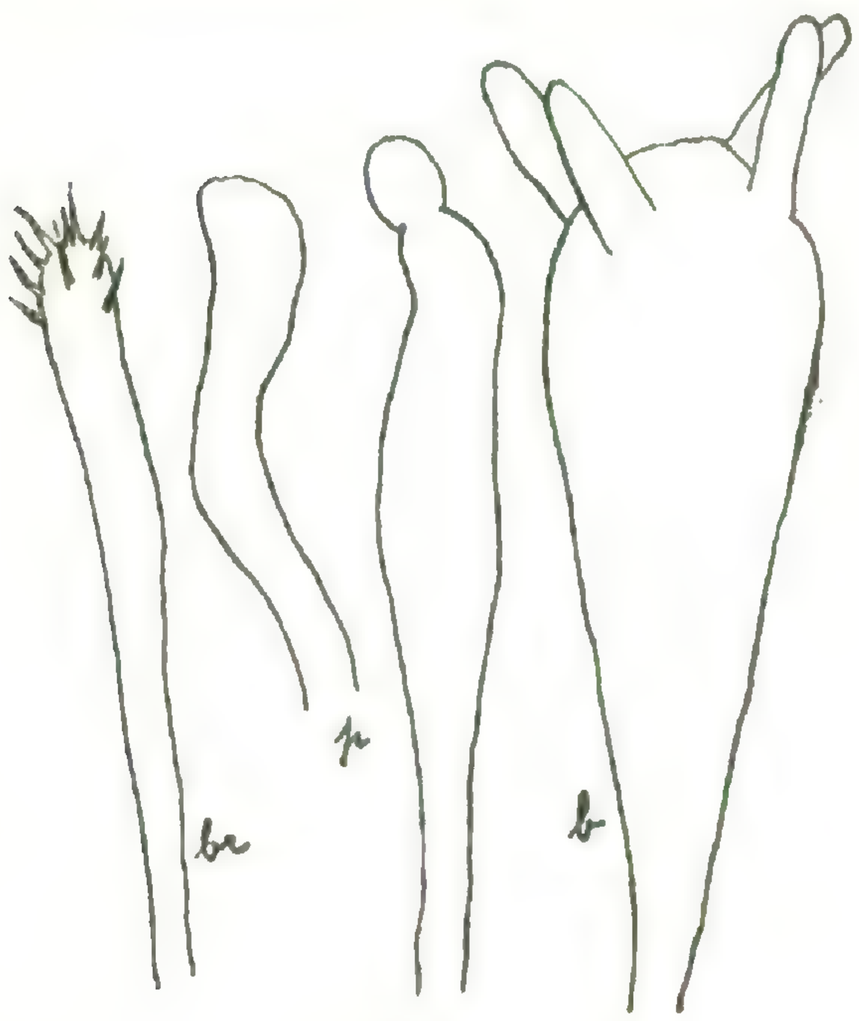

Fig. 13
A. penicillatus.
Brush paraphyses, *br*; other paraphyses, *p*; basidium *b*. ×870.

This species is so thin and widely effused that it is likely to be regarded as a *Corticium* until examined with a microscope. If sought for especially it could probably be recognized when collected by its buff color and occurrence upon western *Tsuga* and *Pseudotsuga*. The minutely echinulate, globose spores, brush-shaped paraphyses occurring between ordinary flexuous paraphyses, and the thin fructification wholly destitute of crystalline and granular matter are a good combination of characters separating *A. penicillatus* from other resupinate species.

Specimens examined:

Idaho: Priest River, *J. R. Weir, 109, 129* (in Mo. Bot. Gard. Herb., 10811 and 12721).

Washington: Hoquiam, *C. J. Humphrey, 6384;* Sequim, *J. M. Grant,* comm. by Mrs. F. W. Patterson (in Mo. Bot. Gard. Herb., 8936).

Oregon: Eugene, *C. J. Humphrey, 6084,* type.

14. A. Weirii Burt, n. sp.

Type: in Burt Herb.

Fructification resupinate, broadly effused, adnate, glabrous, becoming cracked into small polygonal masses, drying cartridge-buff, the margin thinning out; in structure 200–900 μ thick, composed of thin-walled, irregular, hyaline hyphae 2 μ in diameter, which bear laterally here and there short, erect branches with ovoid body 15×4–4½ μ, from which radiate 6–12 prongs, each 4–4½ μ long, and constitute the paraphyses at surface of the hymenium; basidia with sterigmata not found; spores hyaline, minutely echinulate, subglobose, 6×5–6 μ in one specimen, 10–12×9–10½ μ in another.

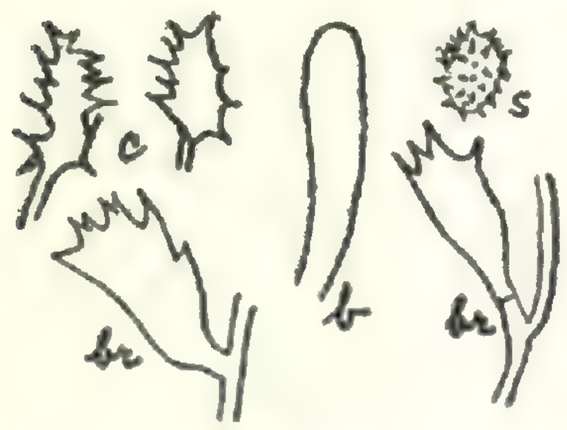

Fig. 14
A. Weirii.

Cockroach-shaped paraphyses, *c;* somewhat similar hyphal branches from interior of section, *br;* immature basidium, *b;* spore, *s.* ×870.

Fructification 1–3 cm. long, 1–2 cm. broad on bark; 8–10 cm. long, 2–3 cm. broad on decorticated wood—broken off at one end and along one side in the latter specimens.

On rotting wood of *Abies grandis* and *Thuja plicata* and on bark of *Larix occidentalis.* Idaho and British Columbia. August and September.

A. Weirii has the aspect of a widely effused *Corticium,* but it is distinguished from any *Corticium* of similar aspect by the minutely echinulate spores; the cockroach-shaped paraphyses distinguish this species from other species of *Aleurodiscus.*

Specimens examined:

Idaho: Priest River, *J. R. Weir, 70,* type, and *389* (the latter in Mo. Bot. Gard. Herb., 12249).

British Columbia: Kootenai Mts., near Salmo, *J. R. Weir, 459, 490* (in Mo. Bot. Gard. Herb., 8768 and 21980 respectively).

(To be continued.)

A NEW SELAGINELLA FROM MEXICO

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In a collection of plants made in southern Mexico in 1908 by Dr. W. J. G. Land and the late Professor Charles R. Barnes was a *Selaginella* which it was impossible at that time to determine with any degree of certainty. Subsequently additional material was obtained and a further attempt was made to identify the plant with some known species, but again without success. Material was then sent to Professor Georg Hieronymus, of Berlin, whose extended studies of the genus had given him a comprehensive knowledge of the entire group. Professor Hieronymus stated that the plant did not correspond to anything in the Royal Herbarium of Berlin, and that it undoubtedly represented a species new to science. The authors take pleasure in dedicating this well-marked species to Professor W. J. G. Land, of the University of Chicago, and present herewith a description and illustrations as follows:

Selaginella Landii Greenman & Pfeiffer, sp. nov.

Herba cespitosa perennis 3–6 cm. vel ultra longa; caule ramibusque prostratis apicibus aliquanto adscendentibus foliosissimis remote radicantibus; foliis crebre pluri-seriatis sub ima parte caulis plus minusve adpressis sed maximam partem adscendentibus vel erectis ovato-lanceolatis vel triangulato-ovatis 1–2.5 mm. longis 0.5–1 mm. latis acuminatis vel acutis ciliatis utrinque glabris supra planis subtus parum convexis et in sicco fere usque ad apicem secus lineam tenuiter sulcatis; spicis (strobilibus) terminalibus 0.5–1 cm. longis erectis vel suberectis tetragonis circiter 1.5 mm. diametro; sporophyllis late ovatis cordatis foliis paulo brevioribus; microsporis parce brevi-spinulosis vel papillosis aurantheo-luteis circiter 46 μ in majore diametro; megasporis

citro-luteis circiter 330 μ in diametro cum costis plus minusve anastomosis obtectis.

A cespitose perennial herb, 3 to 6 cm. or more long; stem and branches prostrate or somewhat ascending at the tips, leafy, remotely rooting; leaves crowded, several-seriate, on the under side of the stem more or less appressed but for the most part ascending or erect, ovate-lanceolate to triangular-ovate, 1 to 2.5 mm. long, 0.5 to 1 mm. broad, acuminate or acute, ciliate, glabrous on both surfaces, flat above, slightly convex beneath and in the dried state narrowly channelled from the base almost to the apex; spikes (strobiles) terminal, 0.5 to 1 cm. long, erect or nearly so, tetragonal, about 1.5 mm. in diameter; sporophylls broadly ovate, cordate, a little shorter than the leaves; microspores sparingly short-spinulose or papillose, orange-yellow, about 46 μ in the greater diameter; megaspores lemon-yellow, about 330 μ in diameter, covered with more or less anastomosing ridges.—Mexico: in dense mats on large rounded granite boulders, San Esteban Mountains, about 32 kilometers from Guadalajara, State of Jalisco, coll. of 1908, *Barnes & Land 2024* (Mo. Bot. Gard. Herb.), TYPE.

This species is related to *Selaginella rupestris* (L.) Spring from which it differs markedly in several characters, notably in having upturned or subsecund and spreading instead of appressed-imbricated leaves and in the absence of bristle-tips at the leaf-apex. In a synoptical treatment of the several species now recognized as belonging to the *S. rupestris* group, *S. Landii* would stand next to *S. Watsoni* Underwood, from which it is readily separated by the ascending or erect leaves on the upper side of the stem, by the absence of an awn at the leaf-apex, and by the smaller megaspores.

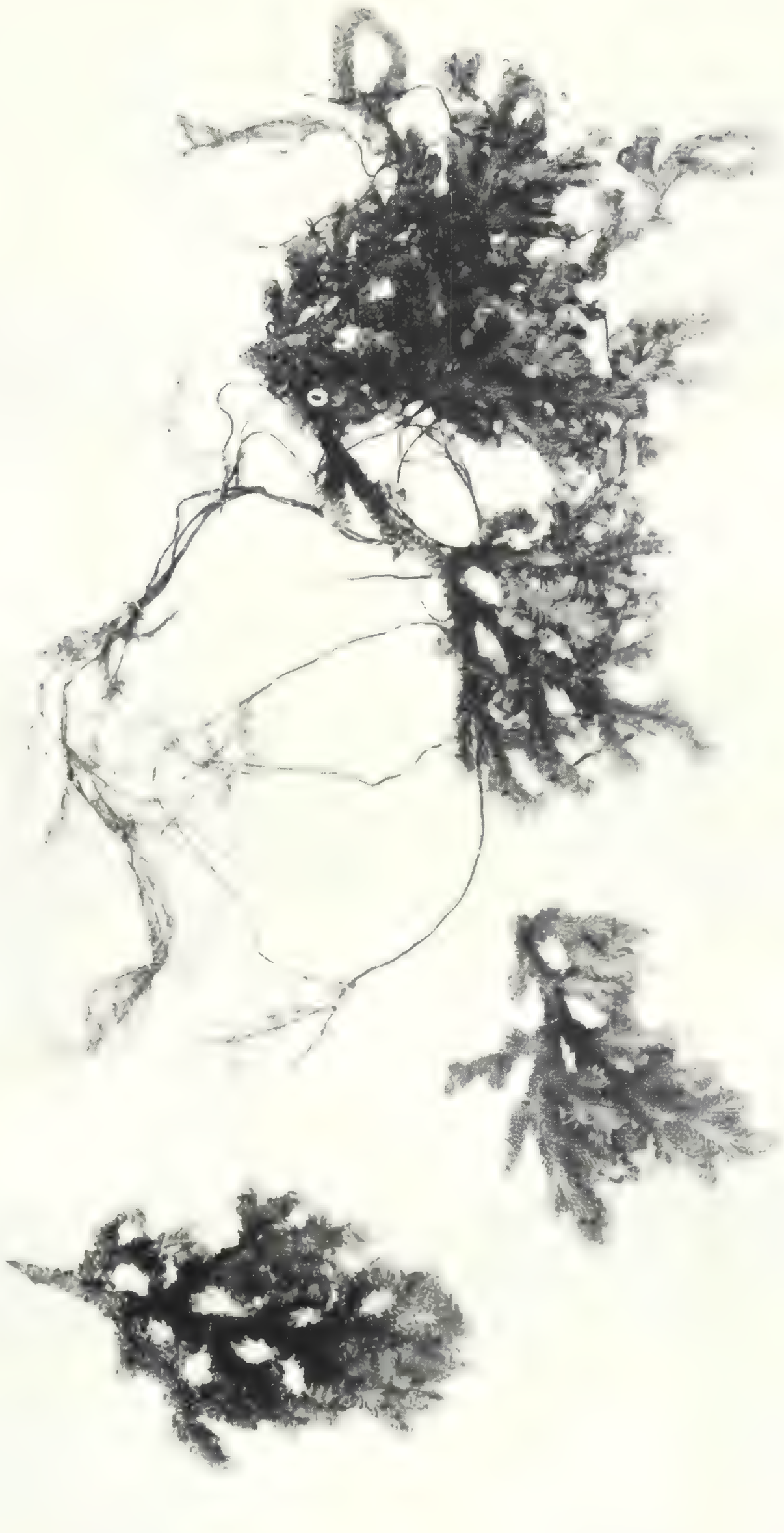
Explanation of Plate

PLATE 11

Selaginella Landii Greenman & Pfeiffer

Mexico

From the type specimen, Barnes & Land No. 2024, in the Herbarium of the Missouri Botanical Garden. Habit of plant; natural size.



GREENMAN AND PFEIFFER—ON SELAGINELLA

Explanation of Plate

PLATE 12

Selaginella Landii Greenman & Pfeiffer

Mexico

From the type specimen, Barnes & Land No. 2024, in the Herbarium of the Missouri Botanical Garden.

Fig. 1. Leaf from dorsal surface of branch; × 44.

Fig. 2. Leaf from ascending tip of branch; × 44.

Fig. 3. Detail of portion of margin of leaf, showing long cilia; × 430.

Fig. 4. Sporophyll; × 44.

Fig. 5. Detail of portion of margin of sporophyll, showing short cilia; × 430.

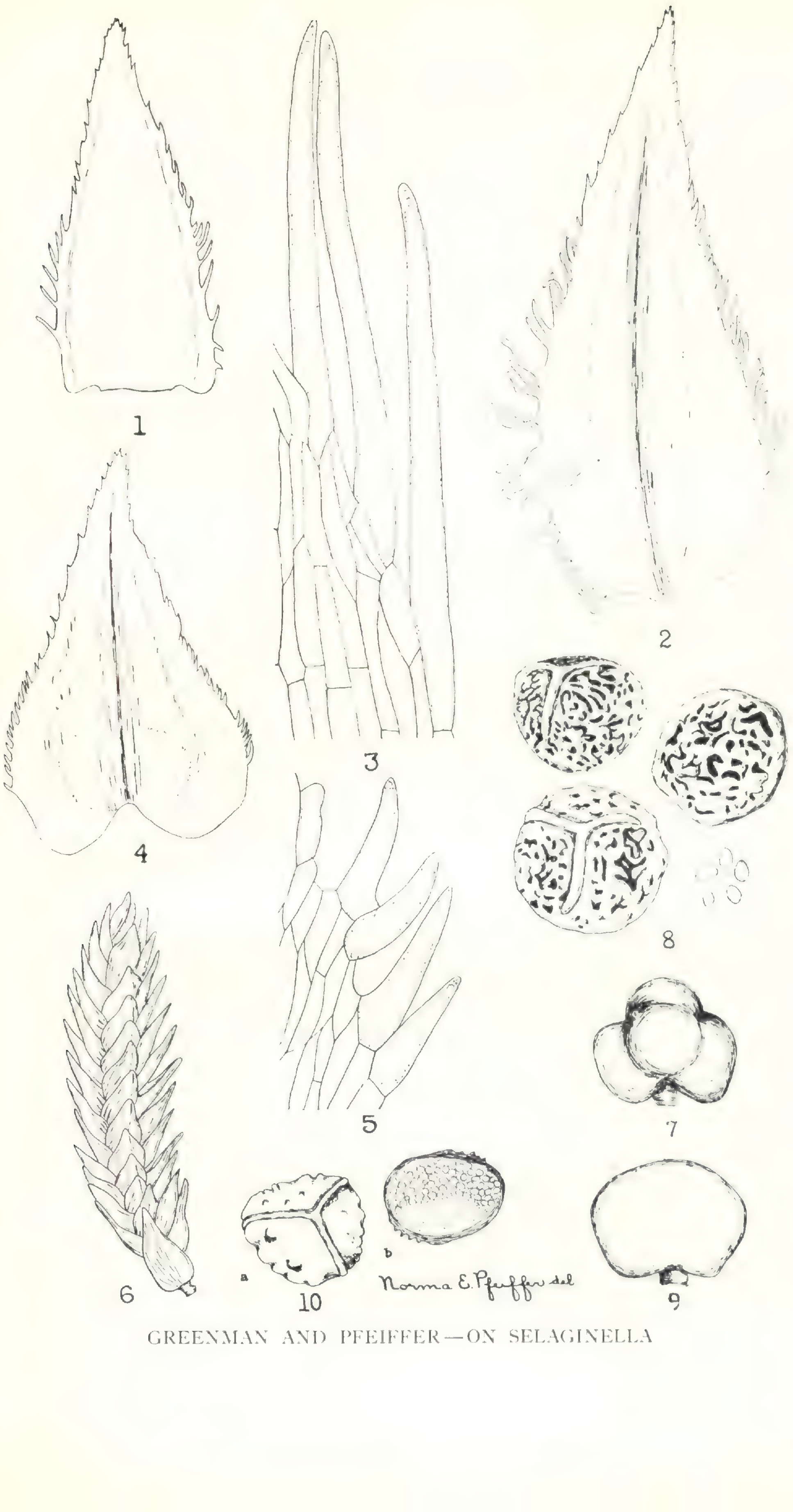
Fig. 6. Spike or strobilus; × 6.5.

Fig. 7. Megasporangium; × 36.

Fig. 8. Megaspores and group of microspores; × 72.

Fig. 9. Microsporangium; × 36.

Fig. 10. Microspores, showing (a) external appearance, and (b) optical section; × 430.



GREENMAN AND PFEIFFER—ON SELAGINELLA

ALGOLOGICAL NOTES

III. A Wood-penetrating Alga, Gomontia lignicola, n. sp.

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Some years ago while collecting on the island of Nashawena, one of the Elizabeth Islands near Woods Hole, Massachusetts, I found in a small fresh-water pond a yellow pine board which was more or less covered with a blue-green slime and accordingly it was taken to the laboratory for further investigation. The blue-greens proved to be nothing unusual, but occasionally there appeared irregular grass-green cells which seemed to be some unicellular form, and, since this could not be identified, the board was retained for further study. Investigation soon showed that the single cells were capable of germination, producing filaments of a millimeter or two in length, but it was not until the last few months, after the alga had been kept under observation for more than six years, that enough of the life history could be determined to identify the genus. Although from the first it was noted that the best way to obtain single cells was to scrape off the accumulation of *Oscillatoria* and *Aphanocapsa* on the surface, it was not recognized until later that the filaments were actually imbedded in the tissues of the wood and that this was not due to disintegration; in fact the pine board was in an excellent state of preservation, the part not submerged partially retaining its yellow color. As soon as the typical sporangia were secured it became evident that the alga was a *Gomontia*,—a fact which, from its habitat, might have been guessed before. But it must be confessed that in spite of this hint, I failed entirely to note the affinities of my plant with that of *Gomontia polyrhiza* until after the life history had been fairly well made out.

While the species to which I shall refer as *G. lignicola* has the well-marked characters of the genus, it differs in several

distinct particulars from the species hitherto described, namely, the original one of Bornet and Flahault, *G. polyrhiza* (Lager.) B. & F.,[1] *G. codiolifera* (Chodat) Wille,[2] *G. arrhiza* Hariot,[3] *G. Holdenii* Collins,[4] and *G. Aegagropilae* Acton.[5] Chodat casually mentions another species, *G. Manxiana*,[6] but there is no description and no discussion which would enable one to judge the character of this plant. Miss Acton states that there is no valid reason for separating *Foreliella* from *Gomontia*, and *Foreliella perforans* Chodat should be known as *Gomontia perforans* (Chodat) Acton, so perhaps this species should likewise be added to the list.

VEGETATIVE CONDITION

The filaments of *G. lignicola*, neither in their general appearance nor in their habit of growth, closely resemble the various species of the genus hitherto described. Except in young plants developing directly from zoospores (pl. 13, fig. 4) the individual cells are almost constantly cylindrical in form, from three to ten times longer than wide. Branching is so infrequent as to lead one to suppose the filament to be typically simple, although occasionally lateral branches of a few cells only may occur. The beginning of such a branch is shown in pl. 14, fig. 4. No indication of the rosette arrangement of branched filaments described for *G. polyrhiza* was observed, and the habit of growth precludes any such formation.

A most striking appearance is produced in the filament by the rather common condition of having the most of the chlorophyll concentrated in the terminal cell. A filament of a dozen or more cells, all approximately of the same size and shape, will, with the exception of the terminal cell, be so devoid of color as to give the appearance of a fungous hypha. Closer examination under a high-power objective reveals a thin thread-like chloroplast which runs for the length of the cell,

[1] Bornet, E., et Flahault, C. H. Soc. Bot. Fr. Bul. **36** : CLII. 1889.
[2] Chodat, R. Bul. de l'Herb. Boissier **6** : 443. 1898.
[3] Hariot, P. Soc. Bot. Fr. Bul. **38** : 417. 1891.
[4] Collins, F. S. Erythea **5** : 95. 1897.
[5] Acton, E. New Phytol. **15** : 102. 1916.
[6] Chodat, R. Algues vertes de la Suisse **1** : 61. 1902.

but the contrast between the brilliant bright green terminal cell and the pale, almost colorless, contiguous cells arrests the attention at once. If the spore from which the filament has arisen be still attached, as is frequently the case, it too may retain its brilliant green color, giving the effect of two algal cells being held together by a fungal thread (pl. 14, figs. 1, 4, 5). That this condition is perfectly normal and not due to any parasite or injury to the colorless cells is easily demonstrated by watching the formation of new cells as they are cut off apically from the original cell. It is as though the full supply of chloroplast material for the entire filament were contained in the apical cell and only enough supplied to the new cell to maintain it. The temptation to speculate upon the possible explanation of this phenomenon, which, together with the wood-penetrating habit, may be so easily construed as another indication of the origin of certain aquatic fungi from algae, is resisted in order that those who are more interested in this sort of thing may have the entire field to themselves.

The composition of the cell wall, as well as the cell contents, is typically Gomontia-like. No reaction for true cellulose is obtained either from the delicate wall of the young cells or the cutinized older and much thickened walls. From one to six rather large nuclei may be observed in each cell, and these do not seem to be, as suggested by West,[1] "due to the incipient formation of resting akinetes." A single chloroplast, which, because of its reticulate and irregular character, frequently gives the appearance of numerous disk-shaped or elongated color bodies, is present and a varying number of pyrenoids can usually be made out. Starch is very abundant in the resting cells, but may or may not be detected in the actively growing vegetative cells. Protoplasmic connections between the cells can easily be discerned, particularly in those cells practically devoid of chlorophyll (pl. 13, fig. 2).

Sporangia

Except for the absence of "rhizoids" the formation and general character of the sporangium of *G. lignicola* agree well

[1] Algae 1 : 305. 1916.

with the description of *G. polyrhiza*. Certainly, as Bornet and Thuret say, "Rien de plus variable que la configuration des sporanges." No two of the large number observed are of the same size or shape, and sporangia formed on the surface, a not infrequent occurrence, are just as irregular in outline as those produced in the tissue of the wood. The contents of the sporangium breaks up into zoospores simultaneously and not successively and the spores escape through a small hole invariably produced in the tip of one or more of the branch-like projections from the main body of the sporangium (pl. 14, figs. 2, 3). Bornet and Thuret were not able to observe zoospore discharge and thought possibly the entire sporangium broke up, thus liberating the spores. This is not the case in *G. lignicola,* however. A most satisfactory and simple means of obtaining discharging zoospore material is to transfer sporangia which have developed on unsubmerged parts of the wood. A part of the board which projected above the surface of the water but, because of the cover on the jar, was constantly in a moist atmosphere, was filled with sporangia. If these were removed to a drop of water on a slide, zoospores would almost immediately begin to be discharged, one at a time, through the minute opening. In fact, the best sporangium material was obtained in this way, and it would appear that a habitat permitting at least semi-aërial conditions is best suited for sporangium formation. So far as known, all the other species of *Gomontia* are to be found in situations which may permit either periodical or irregular intervals when the plant is not submerged, and it seems reasonable to suppose that such a habitat is conducive to the formation and discharge of zoospores.

Zoospores

In the account of the original species of *Gomontia,* Bornet and Flahault describe the zoospores as having two cilia of equal length and of two sizes,—a small one measuring 5×3.5 μ and a larger one 10–12×5–6 μ. No conjugation, either between small ones of the same size or between a large and

small one, was observed. The direct germination of the large zoospore is, however, described.

Wille[1] definitely detected four cilia in zoospores of *G. polyrhiza*. The sporangia from which these came, however, can hardly be regarded as typical, since they were only about 15 μ in diameter and but from two to four zoospores were produced in a single sporangium.

The zoospores of no other species have been satisfactorily described and various authors have given the number of cilia for the genus as either two or four, according as to whether they followed Bornet and Flahault or Wille, or as in some instances regarding the biciliate spores as gametes and the quadriciliate as true zoospores.

All of the motile spores seen from the plants of *Gomontia lignicola* possess but two cilia (pl. 13, fig. 3). Because of the above described method for obtaining these spores an unusual opportunity was afforded to examine zoospores before, during, and after discharge. Thousands were seen and hundreds stained with weak iodine, which was sufficient to demonstrate the cilia. In no case was there the slightest indication of more than two cilia. Neither was there any marked difference in size as described for *G. polyrhiza*. The contents, however, of the zoospore of *G. lignicola* corresponds well with that of *G. polyrhiza*, having the single pyrenoid, a basal chloroplast, and the distinct red spot described for that species.

The possibility of *Gomontia* being one of the genera which possess a quadriciliate zoospore and a biciliate gamete has, of course, been recognized from the first. There is no account, however, of conjugation being seen, and the existence of gametes in *Gomontia* is based upon analogy rather than upon observation. So far as *G. lignicola* is concerned it can, I think, be regarded as highly improbable that gametes occur, at least it is certain that the biciliate bodies observed function as true zoospores. The fact that at least several hundred sporangia were from time to time observed discharging zoospores

[1] Über die Zoosporen von Gomontia polyrrhiza (Lagerh.) Born. et Flah. Norske Videnskab. Selsk. Skrif. **1906**[3]: 29. 1906.

and that the majority of these spores were followed through their germination, both in mixed cultures and under control conditions, justifies one in the belief that there is no foundation for the idea that simply because biciliate and quadriciliate spores have been recorded in *Gomontia* those possessing two cilia are gametes.

Germination of Zoospores

The germination of the zoospore may occur in one of two different ways, there being no visible distinction between those which produce a vegetative filament direct and those forming resting spores which in the past have erroneously been regarded as akinetes or aplanospores. The direct germination of a zoospore to produce vegetative cells was observed by Bornet and Flahault and regularly occurs in *G. lignicola* (pl. 13, fig. 4). Fully as many zoospores fail to germinate immediately, but after losing their cilia assume a spherical form and grow into a large irregular-shaped cell which ultimately produces, at from one to several points, vegetative filaments (pl. 14, figs. 1, 5). Although the method of forming the mature thallus is, of course, different, this body may roughly be likened to the polyhedral cell formed by the zoospores of *Hydrodictyon*. The zoospores which develop into resting spores, instead of germinating directly, retain the red spot for several weeks and the process of growth into a mature resting spore is a slow and gradual one. There is almost as much irregularity in the ultimate size and shape of the resting spore as there is in the sporangium. Plate 15 gives some idea of the great diversity in form of these spores but there is no limit to the variety which might have been shown, since scarcely any two are of the same outline. These spores were the cells first found by me in examining the scrapings from the pine board, and it must be confessed that even after their origin was discovered they were suspiciously reminiscent of certain unicellular grass-greens which have been described.

The resting spores derived from zoospores are brilliantly green in color and full of starch. A single pyrenoid is plainly

visible in the young cells, but as they become more mature no pyrenoids can be observed. Simple staining methods showed but one nucleus. Later the cells became so packed with chlorophyll and starch that it was not possible without sectioning to determine satisfactorily whether or not this nucleus divided previous to the actual germination of the spore. The wall of the resting spore is always decidedly thickened at maturity and various lamellate excrescences and protuberances, referred to by other authors as "rhizoids," are not infrequently formed. The spore, after reaching mature size, may rest for months or even years. No change in nutrient solution or environment seemed to have the slightest effect on inducing germination, although almost every conceivable combination was tried. From time to time certain spores, either in pure or mixed cultures, would begin to germinate and there was no correlation between the results and the treatment to which the various cultures had been subjected.

The germination of the resting spore may apparently take place at any point and usually germ tubes push out at more than one place on the surface of the cell. Ordinarily these do not appear simultaneously but after a filament of several cells has been produced a new filament will start at some other point and this may be repeated until as many as four new filaments arise from a single spore. The resting spore is seemingly inexhaustible, retaining its bright color and abundant starch content until all the filaments produced are of considerable length. Then it slowly disintegrates, frequently leaving remnants of the old spore wall attached to the basal cell of the filament.

Aplanospore or Akinete?

In the original account of *G. polyrhiza* Bornet and Flahault describe what they termed aplanospores. These were about 4 μ in diameter, the size of the small zoospore, and their development into large irregular cells which persisted for a long time without change is practically the same as described above for the resting spore. In fact there can be no doubt that the

resultant body from the so-called aplanospore of Bornet and Flahault and that described by me as originating from a zoospore is the same thing. It will be recalled, however, that Bornet and Flahault never saw the discharge of either the zoospores or aplanospores, nor did they observe the germination of the small zoospores described by them. It would therefore seem possible that the so-called aplanospores of Bornet and Flahault were nothing but zoospores which had come to rest. Plate 13, fig. 5, shows a few zoospores which, failing to escape, rounded up and began the development of resting spores. These might easily be mistaken for aplanospores. Certainly in all the material of *G. lignicola* which was examined under much more favorable circumstances than was possible by Bornet and Flahault, at no time was there the slightest indication of the production of an aplanosporangium or anything which might be regarded as a true aplanospore. Furthermore, in the description of no other species of *Gomontia* is there given any evidence of the existence of aplanospores, their presence in the genus being based apparently entirely upon the original account of Bornet and Flahault. It seems very doubtful, therefore, that aplanospores exist in any species of *Gomontia.* The authority for West's[1] statement that akinetes are found in *Gomontia* is apparently based upon Chodat's account of *G. codiolifera;* at least he cites a figure from Chodat as an example of akinete formation. Chodat called this figure an example of "états Codiolum deviennent finalement des zoosporanges." It is without doubt a resting spore developed from a zoospore, and, so far as known, there is no justification for considering akinetes as existing in any species of *Gomontia.*

Gomontia lignicola Moore, n. sp.
Type: in Mo. Bot. Gard. Herb.
Filaments usually simple, rarely branched, not radiating from a common center; a single parietal chloroplast much reticulated, usually most abundant in apical cell; numerous pyrenoids; 1–6 nuclei; mature cells 25–45 μ in width, 100–200 μ in length; zoosporangia typical for the genus; zoospores

[1] Algae 1 : 305. 1916.

biciliate, 10–12×12–15 μ; germination either direct or by producing large irregular-shaped resting spores which germinate direct, producing one or more vegetative filaments; no aplanospores or akinetes observed.

Growing within tissue of wood (yellow pine) submerged in fresh water; to be regarded as at least partially aërial in habit. Fresh pond on Nashawena, Elizabeth Islands, Massachusetts.

Explanation of Plate

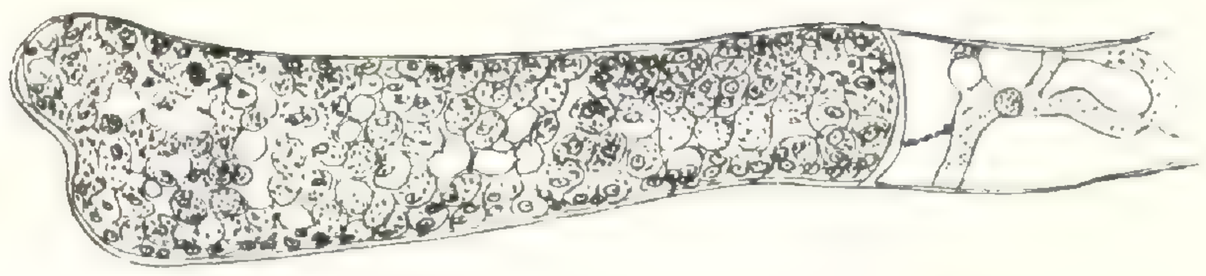
PLATE 13

All figures are reproduced from camera drawings × 580.

Figs. 1 and 2. Terminal and contiguous vegetative cells, showing difference in chloroplast, also protoplasmic connection.

Figs. 3 and 4. Zoospores and direct germination.

Fig. 5. Zoospores which have come to rest within sporangium.



1

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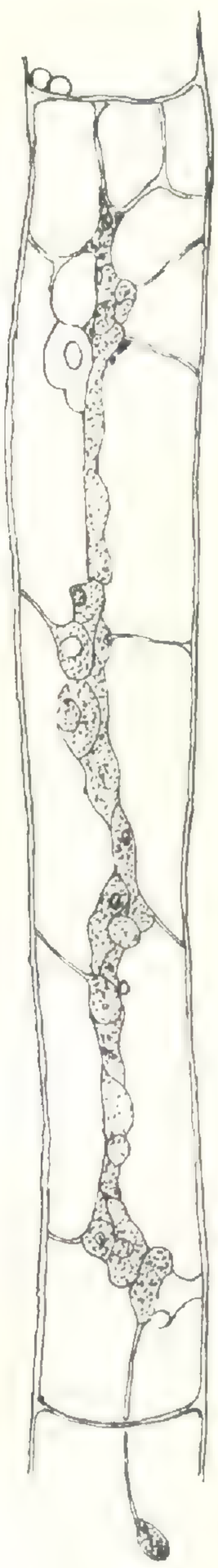
4

5



2

MOORE—GOMONTIA LIGNICOLA

EXPLANATION OF PLATE

PLATE 14

All figures are reproduced from camera drawings × 100.

Figs. 1, 4, and 5. Germinating resting spores, showing vegetative filaments.

Figs. 2 and 3. Sporangia partially empty.

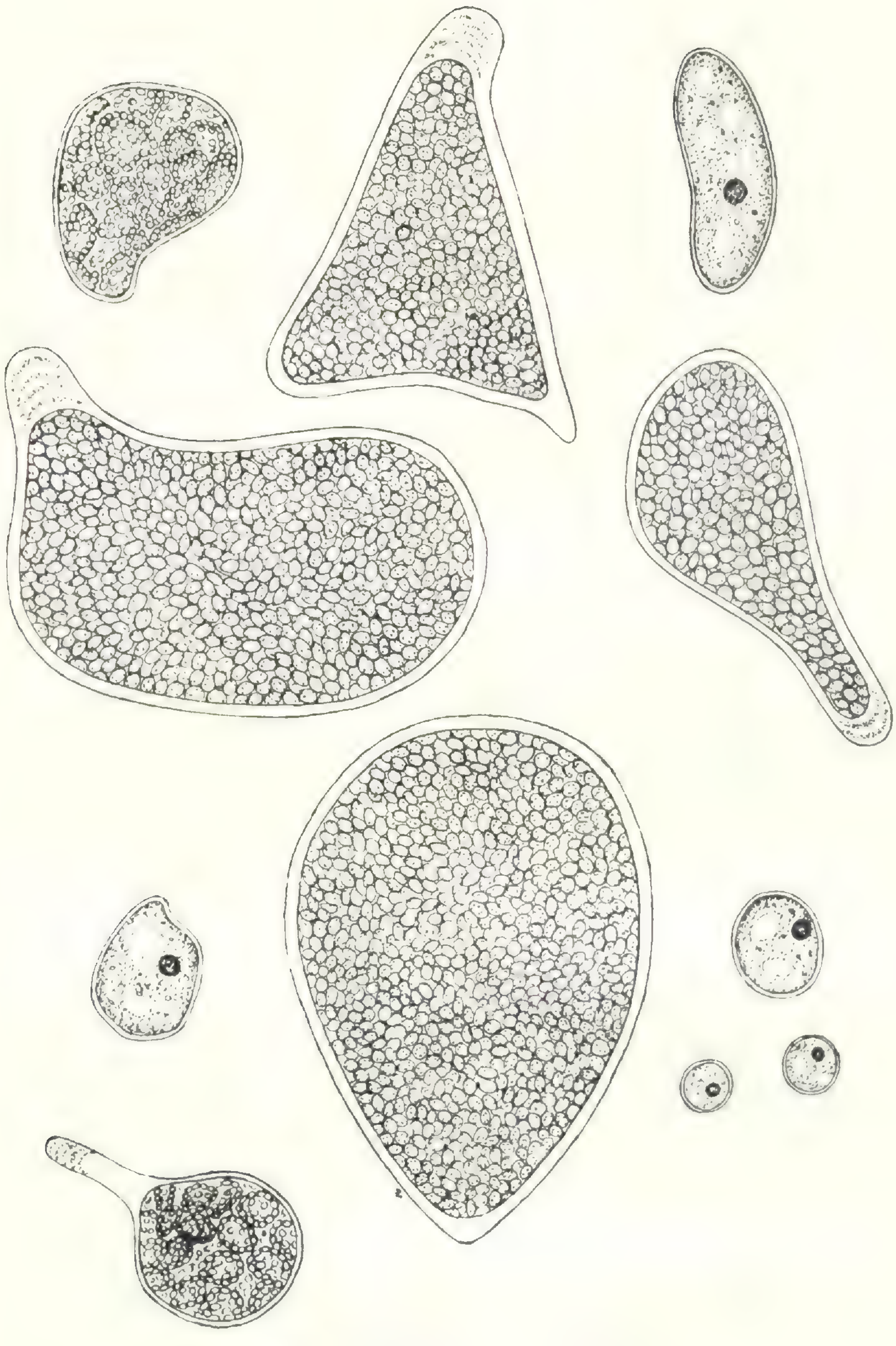
MOORE—GOMONTIA LIGNICOLA

Explanation of Plate

PLATE 15

All figures are reproduced from camera drawings × 580.

Various stages in development of resting spores from zoospores, as well as a few examples of mature resting spores.



MOORE—GOMONTIA LIGNICOLA

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ETHERIZATION OF TISSUES AND ITS EFFECT ON ENZYME ACTIVITY

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In the years following the discovery of anaesthesia by ether and other substances a great amount of work has been devoted to the study of the stimulating and inhibiting effects of various factors on plants and animals; the literature on the subject is voluminous. A knowledge of the range of chemical compounds capable of producing a form of either stimulation or anaesthesia (and we shall see that these contrasting phenomena are closely allied with respect to the causal agent) has vastly increased, and embraces many substances, both organic and inorganic, which do not ordinarily come to mind as anaesthetics. No attempt will here be made to review, except incidentally, the work in the domain of animal physiology bearing on the anaesthesia question; neither is it germane to the present study to consider more fully the literature relating to stimulation and inhibition caused by other agents than those commonly regarded as anaesthetics, i. e., ether, chloroform, and chemically related substances.

SURVEY OF LITERATURE

EFFECT ON IRRITABILITY

Effect on growth and turgor movements of complex members.—Probably the first experiments with ether in the field of plant physiology are those of Clemens ('47, '48, '48[a]) and of Marcet.[1] The former found that *Mimosa pudica* and

[1] Cited by Hempel ('11) and by Rothert ('03).

stamens of *Berberis* lost their sense of irritability in vapor of acetic or sulphuric ether. Leclerc ('53), also studying *Mimosa,* noted a like loss of irritability, with subsequent recovery when the dose was not excessive, and concluded that plants possessed a nervous system analogous to that of animals. Loss of irritability varied with light conditions, being accelerated in direct sunlight. Kabsch ('61) noted that the periodic movement of the leaflets of *Hedysarum gyrans* L. was inhibited by ether and by chloroform and that these vapors were lethal in their effect except in minimal doses of the former. *Mimosa pudica* was still a favorite object of study, indicated by the work of Blondeau ('67), who confirmed Leclerc and came to similar conclusions, and by the observations of Bert ('67), who concluded that the paratonic movements alone were affected by etherization. Pfeffer ('73) did not subscribe to this view, since he found that sleep movements also were suspended by such treatment.

Carlet ('73) observed a retardation in nutation of the anthers of *Ruta* when subjected to ether or chloroform, although movement was not completely inhibited. Under the influence of the anaesthetics the pollen sacs did not open. Heckel ('73) found that stamens of *Berberis* lost the power of irritability in a chloroform atmosphere, while those of *Ruta* were unaffected, and he supported Bert's view of two classes of plant movements—spontaneous and induced. Heckel's observations along this line ('74, '74[a], '74[b], '74[c], '74[d], '74[e]) led him to conclusions regarding the seat of response to anaesthetics which Pfeffer ('75) has criticized as based on errors of technique and misinterpretation of factors involved. A later study by Heckel ('76) of *Drosera* and *Pinguicula* was concerned with variations produced by different doses of the anaesthetics. Darwin ('75) studied the effect of ether and chloroform upon the movement of the tentacles of *Drosera,* noting loss of irritability and subsequent recovery when restored to normal conditions. The classic experiments of Bernard ('78) also included the response of *Mimosa* to anaesthetics.

Siragusa ('79), noting the effect of ether on various manifestations of higher and lower plants, saw that the spontaneous periodic opening and closing of flowers was inhibited in an atmosphere of that vapor. Arloing ('79) substantiated the previous findings with respect to *Mimosa*. Macchiati ('80) concluded that the inhibitory action of chloroform and ether upon stamen movements in *Ruta* and *Smyrnium* was due to the temperature reduction effected by the vapors, although Cugini ('81) attempted to disprove this point by experiments with the same anaesthetics under super-normal temperatures, to which Macchiati ('83) took exception. Tassi ('84, '87) followed with a study of the effect of volatile and non-volatile anaesthetics on cut flowers in conditions of diffuse light. He observed a paralyzing effect upon perianth movements. Temperature reduction apparently played no rôle in explaining the results, since similar action occurred with the non-volatile substances. Macchiati ('84), however, endeavored to show that these results were open to question because of the use of anaesthetic dosages of lethal concentration.

References to the effect of anaesthetics on special tropic response are not numerous. Molisch ('84) reported that the roots of maize seedlings were negatively tropic to atmospheres of nitrous oxide, chloroform, ether, and other vapors and gases. Czapek ('98) in his extensive study of geotropic stimuli found that chloroform in aqueous solution increased the geotropic induction time as well as the reaction time for roots of *Vicia* and *Lupinus* seedlings. Bertel ('02) noted a geotropic after-effect of chloroform on the roots of *Lupinus* seedlings in the course of metabolism studies. Wächter ('05) reported what he designated as chemonastic response in the case of *Callisia repens* where the leaves were made to droop notably as the result of exposure to ether, illuminating gas, and other gaseous atmospheres.

Effect on microörganisms. — The field of microbiology, using this term in a very general sense, has received some attention with respect to the effect of stimulants and anaesthetics on functional and tactic responses. Thus Bernard ('78) recorded the inhibition of dextrose fermentation by

yeast in presence of chloroform. Siragusa ('79) reported the failure of long ether exposure on subsequent activities of bacteria, yeasts, and molds, but this early work may be questioned. Elfving ('86), studying yeasts among other objects, noted increased carbon dioxide production by such organisms from dextrose and asparagin in presence of narcotics. Swarm spores of *Chlamydomonas pulvisculus* showed a reversal of phototactic response from negative to positive in the presence of ether. Chloroform, on the other hand, proved toxic.

Rothert ('03) essayed to determine tactic effects of anaesthetics on microörganisms as distinct from effect on motility, and reported varying chemotactic inhibition effects of ether. *Bacillus Solmsii* had its chemotactic response inhibited by this substance, but not by chloroform. *Gonium pectorale,* on the other hand, was partially affected as to phototaxy by chloroform. Rothert also recorded a noteworthy reversal of phototactic response (negative to positive) and a shifting of the light intensity optimum. An osmotactic susceptibility was completely inhibited by a narcosis which only inhibited chemotaxy and "aërotaxy" to varying degrees. While motility was found to depend on length of exposure, anaesthetic effects were held to bear a relation solely to the concentration used. A distinction is thus made between a narcotic and a progressive toxic action.

The results of the studies of Herzog and Hörth ('07) on the effects of vapors on yeast autolysis will be considered under another heading. The fermentation experiments of Koch ('11) indicated a definite stimulus to activity of yeasts by small ether dosages. Fred ('11) also noted a stimulus to bacterial growth effected by ether in small concentrations, and even reported an increased nitrogen-fixing capacity of *Azotobacter* in pure culture as a result of etherization. Harvey ('15) has found that when ether or chloroform, among a series of compounds tested, was added to tubes containing a sea-water emulsion of luminous bacteria, the light emitted by the organisms disappeared almost immediately. He does not state, however, whether the action is reversible, as was the case with various alcohols used.

Effect on protoplasmic streaming.—Ewart ('03) cites Kühne as probably the first to show that chloroform and ether inhibit protoplasmic streaming. Dilute solutions at first caused stimulation, while concentrations of 10–25 per cent saturation caused immediate retardation. The reversal of the action, if the normal environment was restored after a short inhibition period, was also substantiated by Hauptfleisch ('92). Retardation of streaming in hairs of *Primula, Petunia,* and *Lycopersicum* was also reported by Schneider ('93). Demoor ('95) noted the initial stimulus of chloroform on the protoplasmic movement of *Tradescantia,* with marked vacuolization for a short period preceding anaesthesia. Pre-anaesthesial excitation of the nucleus, he observed, was greater than that of the cytoplasm. Recovery of normal functions varied with the individual objects studied, which included cells of *Fumaria,* and leucocytes.

The observations of Farmer and Waller ('98) are in general a confirmation of the work already cited. The materials studied in this case were *Chara* and *Elodea.* On the other hand, the findings of Demoor are controverted in part by Samassa ('98–'01?), who noted that with complete inhibition of protoplasmic streaming in *Tradescantia,* nuclear division does not continue, but an inhibitory after-effect of varying duration results.

Josing ('01) approached the problem from another viewpoint, considering the effect of the anaesthetics, among other factors, with respect to the environment. *Vallisneria, Elodea,* and *Trianea* were studied, and treatment resulted in cessation of streaming in darkness and a renewal of activity in light. An aqueous solution of ether of definite concentration increased the length of time of streaming in light. Deviation from this optimum on either side resulted in time reduction. Streaming under unfavorable temperature conditions continued for a longer period in etherized plants than in controls. In the absence of oxygen or in the presence of carbon dioxide the period of streaming in control plants was greater than in those previously etherized.

EFFECT ON GROWTH ELONGATION AND CELL DIVISION

Growth responses to the agents with which we are here concerned have also occupied the attention of several botanists. Siragusa ('79) noted growth inhibition of both aërial and subterranean organs of higher plants. Detmer ('82) also found that chloroform inhibited the growth of *Pisum* and *Triticum* or impeded it notably, with reduced respiration. Elfving ('86) reported inhibition of growth of sporangiophores of *Phycomyces nitens* for short periods as the result of ether treatment, without subsequent recovery. Bateson and Darwin ('87) studied the effect of ether and chloroform vapors on pith elongation of *Helianthus,* using auxanometric methods, and found that ether effected a distinct increase in length, varying with the dosage employed. Chloroform had a variable effect, acting as a stimulant in one case; with weaker dosage, however, there was either inhibition or no effect.

Townsend ('97) subjected leaves of *Avena sativa* to ether atmospheres of different concentrations for varying periods. Retardation of growth was found to vary with increase of ether concentrations in the atmosphere. Weak concentrations first produced a retardation, followed by a distinct stimulus. In some cases the stimulus to growth did not become evident for a day, and then lasted throughout the period of the experiment. Longer exposure resulted in retardation for two days, followed by a return to normal growth rate without any intermediate period of acceleration. Sandsten ('98) also recorded a growth acceleration caused by weak ether and chloroform dosages on seedlings of *Zea Mays,* and a retarding action of stronger concentrations. Resting bulbs were killed by long exposure to weak doses. Latham ('05) studied the relation of chloroform to the growth of *Sterigmatocystis nigra* and of *Penicillium glaucum.* She found the usual concentration relations to hold,—growth stimulation with small doses and inhibition or death following the use of large ones. The effect of a given dose increased with rise in temperature. The increased growth observed was attributed to increased

metabolic economy, on the basis of less sugar consumed and less acid formed.

Burgerstein ('06) found that a very low ether content in air (.004 per cent) accelerated the hypocotyl growth of *Phaseolus, Cucurbita,* and *Helianthus,* while the same chloroform dose produced varying degrees of inhibition. Finally, Schroeder ('08) studied the effect of ether on the growth of *Avena sativa* seedlings, using the horizontal microscope under constant temperature conditions. He concluded that the effect of ether upon growth was a function of concentration and length of exposure. The first effect was stimulation, followed by a subnormal depression. With increased dosage the latter was more marked and occurred more rapidly until concentrations were reached where growth inhibition was immediate and death resulted.

Studies of anaesthesial action on cell structure have been reported by Nathansohn ('00), Sabline ('03), von Wasielewski ('04), and Gerassimow ('05). Nathansohn studied the effect of ether solutions on *Spirogyra* and *Closterium* and observed abnormal nuclear divisions in the latter. *Spirogyra* showed neither form of mitosis under the influence of ether. Sabline concluded from a study of various chemical agents employed that sulphuric ether effected abnormal cytologic changes in the nuclear stages of root cells of *Vicia Faba.* Von Wasielewski obtained amitotic figures in root tips of the same plant with 0.5 and 1 per cent chloroform water, but negative results with 1 per cent ether solutions, although in the latter case he observed an increase in the number of normal mitoses. Gerassimow believed from his study of *Spirogyra* in ether cultures that the increase in thickness of the cell, which occurred only where nuclei were present, indicated nuclear stimulation. Weak ether dosages increased response to stimuli and accelerated budding and general metabolic processes.

EFFECT ON GERMINATION

Observations on germination with respect to anaesthesia treatment occur in the literature, beginning with the work of Claude Bernard ('78), who noted the inhibitory action of

ether on sprouting seeds. Siragusa ('79) confirms such inhibition, but also points out the subsequent recovery therefrom. Giglioli ('82) studied the action of gases and liquids on the vitality of seeds, chloroform and ether being among a large number of substances tried. *Medicago sativa* showed a high resistance to both the anaesthetics in liquid form according to the time of treatment,—showing germination of 29 per cent after 484 days' immersion. Romanes ('94) found no appreciable effect on the germination of various seeds subjected to ether or other vapors for long periods, the seeds having been previously stored *in vacuo* for several months.

Townsend ('99) showed that while weak doses of ether accelerated the germination of cereals, vegetable seeds, and fungous spores, stronger ones either retarded or completely inhibited such action. Recovery of activity was also noted when normal environment was restored. Coupin ('99) compared the resistance of dry seeds to inhibitory action of saturated atmospheres of ether and chloroform with that of seeds previously subjected to moist conditions. The former were unaffected; the latter showed inhibition or death from treatments as weak as 37/10000. Duggar ('01) found chloroform to be lethal in one-half hour to spores of *Aspergillus* and *Phycomyces*. Ether had little effect as a stimulus, except in low concentrations, on *Aspergillus*. Opposed to Coupin were the findings of Schmid ('01), who reported that chloroform vapor was lethal to the protoplasm of latent seeds; that the seed-coats in that state were permeable to the anaesthetic vapor to varying degrees, and that injury varied with such permeability. Dixon ('02), in checking the work of Giglioli on the resistance of seeds to toxic agents, found that the resistance to chloroform and other poisons, as indicated by germination after treatment, depended on the integrity of the seed-coat.

Becquerel ('05), in the face of such contradictory findings, attacked the question anew, using seeds of wheat, lucerne, clover, peas, and lupine, both air-dried and dried to constant weight, with seed-coats injured and intact. His results also tended to show that lack of injury depends largely upon the

integrity of the seed-coat. Seeds with uninjured coats remained viable after subjection to anaesthetic vapors or solutions for almost a year; those with perforated coats were killed. Burgerstein ('06) also opposed Schmid's view by reporting that 24 hours' exposure of seeds of *Phaseolus, Cucurbita, Helianthus, Zea,* etc., to ether vapor resulted in germination stimulus, while seeds with previously imbibed water merely suffered a retardation. Chloroform in the same respective dosage was found to be more toxic. The germination of barley was stimulated, according to Kiessling ('11), by subjection to ether vapor for 80 minutes; a longer treatment resulted in a reduction in rapidity and per cent of germination. Hempel ('11), on the contrary, found that ether retarded the germination of *Pisum* seedlings.

EFFECT ON PERIODICITY

Under this heading may be grouped the investigations dealing with the forcing effect of anaesthetics on growth activity, as distinct from effects on germination as a phase of growth. Such forcing action of ether vapor in breaking or suspending the period of inactivity in the annual cycles of many plants has been the subject of considerable experimentation since Johannsen ('06) first called attention to the subject. A large part of the literature on the subject deals with methods and results as applied in the floricultural and horticultural field, and no review of the publications bearing on this phase is here attempted. Mention may be made of the work of Aymard ('04), Howard ('06, '10, '15, '15[a], '15[b], '15[c]),—who has devoted a considerable amount of time to experimental work along this line with twigs, potted plants, bulbs, herbaceous perennials, and seeds,—and the experiments of Stuart ('10).

Behrens ('06) regarded the shortening of the rest period of seeds by ether vapor as a pure stimulus effect independent of seed-coat permeability. Burgerstein ('06) noted a forcing action on bulbs of *Narcissus* with the same ether dosage that caused inhibition in *Allium Cepa.* Tulips, he reported to be unaffected by the anaesthetic. Jesenko ('11) varied the

experimental method by forcing solutions of ether under pressure into the cut ends of twigs. The lower concentrations used acted as stimulants, causing bud development if treatment occurred during the normal rest period of the plant; otherwise action was injurious.

EFFECT ON TRANSPIRATION

In the field of transpiration studies Jumelle ('90, '90[a]) found that the effect of ether in darkness was to decrease the action, while the same dosage had an accelerating influence in the light. He concluded that the anaesthetic acted on the chlorophyll and increased transpiration by converting all the energy in that direction, while assimilation was inhibited. His findings appear to be confirmed by Lommen in a brief note by MacMillan ('91), the former having measured the loss in weight of *Selaginella* following etherization. Schneider ('93) explained the increased water loss observed in his experiments as evaporation from tissues killed by the anaesthetic. Woods ('93), however, points out the error in these deductions, and on the basis of his investigations on *Canna indica* and *Mnium sp.* confirmed Jumelle's findings and explained the increased water loss in light as compared with plants in darkness purely on the physical basis of increased evaporation in daylight from the living tissues.

Darwin ('98) in an extensive study of stomatal response found that both chloroform and ether vapors caused a partial closing of stomata without subsequent injury. A careful study of anaesthetic effects with reference to water loss as related to plant activity was made by Dixon ('98), who gave special attention to the physical factors involved. Dixon found that ether and chloroform produced inhibition in both rate and amount of transpiration of cuttings, in contrast to an acceleration effected by oxygen. When, however, the specific transpiration in various atmospheres, based on air as standard, was compared with the specific evaporation of water in atmospheric currents of the same substances it appeared that, with the exception of oxygen, there were no marked differences within limits not lethal to the plants. The

conclusion was reached that anaesthetics among other vapors are without effect on photosynthetic action of leaf cells with respect to transpiration.

EFFECT ON RESPIRATION AND PHOTOSYNTHESIS

The study of the respiratory function as influenced by anaesthetic action has been a subject of inquiry since the days of Bernard. Gayon ('77) reported complete inhibition of respiration ("fermentation intracellulaire") of fruits by ether and chloroform. Schwarz ('81) reported that the presence of these substances in water effected a cessation of oxygen evolution and carbon dioxide assimilation in *Elodea* and *Ceratophyllum* without subsequent recovery. This opposed Bernard's conclusions ('78) that chloroform inhibited assimilation while respiration continued. Bonnier and Mangin ('86), using their method of gas analysis, were able to show that with the use of a measured amount of ether carefully added, carbon dioxide assimilation was checked without affecting respiration, thus confirming Bernard and opposing Schwarz.

Pringsheim ('87), in a study of assimilation and respiration of chlorophyllous plants, using the bacterium method, found that ether and chloroform inhibited assimilation, that such action was accompanied by death of the cells, and that the chlorophyll apparatus was changed.

Laurén ('91) studied the effect of ether on the respiration of various seedlings, and determined both aërobic and anaërobic respiration. Different plants gave varying response. The normal respiration of *Ricinus* and *Lupinus* was increased; of *Pisum, Phaseolus,* and *Cucumis* increased to a maximum with a certain per cent concentration, and decreased with higher ones. *Brassica, Hordeum,* and *Zea* were unaffected by weak dosages and inhibited by stronger ones. The anaërobic respiration of *Lupinus* and *Pisum* was increased, while this was not noted in *Ricinus, Zea,* and *Hordeum.* No explanation was offered for these differences, but attention was called to the fact that seedlings rich in carbohydrates

showed no respiratory response in comparison with those containing a high per cent of protein.

Ewart ('96), in his early work on this subject, came to conclusions similar to those of Schwarz. Kny ('97) found that *Spirogyra* anaesthetized with chloroform water until plasma movement had ceased, the nucleus become swollen, and the chloroplasts distorted, still retained its chlorophyllous functions. He concluded that injury to cytoplasm and nucleus was not directly correlated with the chlorophyll function. Ewart ('98), in a later study of *Elodea canadensis,* confirmed Bernard's findings of assimilatory inhibition without permanent injury. Téodoresco and Coupin ('98) studied the effect of ether on etiolated seedlings of wheat, vetch, lupine, and buckwheat. Chlorophyll formation was prevented or retarded according to conditions of dosage or length of exposure. Kauffmann ('99), studying the effect of narcotics on the protoplasmic processes with respect to chlorophyll formation, also showed that inhibition or permanent injury was dependent on strength of dosage and length of exposure. Morkowine ('99), from his experiments, opposed the findings of Bonnier and Mangin, whose error, he believed, resulted from insufficient periods of observation. Morkowine found that respiration intensity increased notably two hours after treatment. Zalenski ('02) also reported increased carbon dioxide evolution from corms of *Gladiolus* following an etherization of 1 cc. per 750 cc. volume, with a subsequent return to normal rate; stronger dosage caused depression. Exposure was shown to be a factor, since a dosage that stimulated after short exposure caused depression when the time of action was prolonged. Kosiński ('02) subjected *Aspergillus niger* to chemical and mechanical stimuli in absence of nutrients; ether dosages to a maximum of 2 per cent increased the respiration, higher ones depressed it, and the presence of 5 per cent in the nutrient solution caused immediate cessation of respiratory activity. Morkowine ('03) in a later paper reported experiments with *Vicia Faba, Beta vulgaris,* and *Gladiolus,* using various stimuli. Ether, among other compounds, showed a varying effect upon carbon dioxide evolution with

respect to intramolecular respiration. A minimum, optimum, and maximum stimulation were evident which were correlated with changes in the intensity of intramolecular respiration. It was found that under the stimulus plants could develop an anaërobic respiration equal to, or greater than, the normal respiration value. The ratio of anaërobic to normal respiration, however, was not found in general to change under the effect of stimuli.

Treboux ('03) concluded that ether and chloroform in weak concentrations increased both growth and respiration of *Elodea,* but did not have a similar effect on assimilation; a suitable dose of chloroform caused assimilation to be temporarily inhibited. Kegel ('05) found reduction or complete inhibition of carbon dioxide evolution in *Elodea canadensis* with chloroform of varying concentrations. Solutions of .4–.7 per cent accelerated assimilation, even where the iodine test showed little or no starch present. Ether gave similar results. The presence of varying amounts of starch in the leaves appeared to have no effect on the response, but variations in different seasons were noted. Schroeder ('07), in determining whether the retardation of respiration by hydrocyanic acid was a primary or secondary effect, used ether for purposes of comparison, and found that with the latter the reduction of respiration was gradual with small doses. With long exposure there was no recovery, as was the case with the acid. The conclusion was reached that the respiratory response to ether was of a secondary nature and resulted from injury as the primary cause.

Palladin ('10), in a study of the effect of toxins on the respiration of living and dead plant tissues, determined the carbon dioxide evolved by corms of *Gladiolus Lemoine, G. Calvilli,* bulbs of *Allium Cepa,* and seedlings of wheat and *Vicia Faba.* Various chemical agents were employed, among them ether. In general the results showed carbon dioxide stimulation by toxins, the effect of which disappeared when the plants were subjected to lethal conditions. The other phase of Palladin's work will be considered later.

Müller-Thurgau and Schneider-Orelli ('10) recorded both carbon dioxide data and sugar content of etherized potatoes previously stored at 0° C. They concluded that etherization,—at least in comparison with the effect produced by heat,—had little effect upon the metabolic processes concerned in the conversion of sugar with which carbon dioxide evolution is associated. These results are open to criticism in view of the fact that in all cases where the effect of ether was studied the tubers were halved, which introduced the important additional wound factor with respect to respiration processes. Irving ('11) has noted the difference in the effect on respiration of single doses of chloroform *versus* continuous treatment, as well as the effect of this anaesthetic on assimilation, using barley shoots or leaves of the cherry laurel. With respect to respiration she found that the effect depended upon the dosage, with a regular progression in the respiration curve between the augmentative effect of minute doses and the inhibitory action of large ones. The increased respiration effected by small amounts of vapor could be maintained if such amounts were continuous, and normal respiration was restored with its withdrawal. Medium dosage resulted in an initial outburst of carbon dioxide followed by a decline much below normal, the rate and extent of decline increasing with the dosage. With stronger doses the initial stimulus fell rapidly to zero. The early period of application was found to be the most effective time, as the same respiration curve was found to hold thereafter when chloroform was withdrawn or continued. The destruction of chlorophyll in barley leaves, with exudation of water from the stomata, and the browning of the cherry laurel tissues and decomposition of the cyanogenetic glucoside were indices of the lethal action of the anaesthetic. Interesting effects on assimilation were also noted. Minute doses which had no detectable effect in darkness arrested assimilation in the leaf in light. Recovery of assimilative powers could be noted following a short exposure to a low concentration. Quite moderate doses abolished all traces of assimilation, while larger ones acted so rapidly that

there was no difference between reactions in light and darkness.

The experiments of Hempel ('11) indicated that small ether dosages of short duration accelerate carbon dioxide production in *Pisum* seedlings, especially at low temperatures, while large doses proportionately retard such action; the after-effect of narcosis was a retardation irrespective of the concentration used. Thoday ('13) investigated the quantitative relation of carbon dioxide evolution and oxygen absorption in relation to chloroform doses, using a modified form of Bonnier and Mangin's eudiometric apparatus. He believes that the increased respiratory activity produced by different agents is not necessarily of the same nature in each case and that a substance so chemically inactive as chloroform may have a relatively simple physical effect. Fresh and starved leaves of cherry laurel (*Helianthus tuberosus*) and *Tropaeolum majus* were used. In cherry laurel a weak dosage showed a stimulation in production of both gases to similar degrees. With strong dosage disorganization was effected, accompanied by a rapid inrush of oxygen, diminished evolution of carbon dioxide, and browning of tissues. With *Helianthus* similar results were obtained, but chloroform penetrated more rapidly. *Tropaeolum* appeared to be intermediate between the other leaves in susceptibility. In many, but not all, cases a relatively greater and more augmented respiratory activity occurred in anaesthetized starved leaves, as compared with the controls. In general this work confirmed that of Miss Irving.

Von Körösy ('14) studied the effect of chloroform solutions on *Elodea* under controlled conditions of temperature, light, and carbon dioxide content of water, using the bubble method. He found a range of aqueous solutions which inhibited chlorophyll assimilation; the average concentration of such solutions was .074 per cent. At such concentration the action was reversible, the usual plant activity being resumed with a return to normal conditions. The chloroform concentration noted was the same as that with which Loeb and Wasteneys obtained their results.

Haas ('17) has recently made an investigation of the effect of various anaesthetics, including ether and chloroform, upon the respiration of *Laminaria*. The change in amount of carbon dioxide evolved was noted in terms of the change in hydrogen ion concentration of the solution in which the fronds were immersed, using indicators and buffer solutions of known hydrogen ion concentration as standards. He found that exposure to anaesthetics in concentrations sufficient to produce any effect resulted in increased respiration; a decrease below the normal amount followed this in cases where the concentration of the narcotic was sufficiently toxic, but no such decrease was noted with non-toxic concentrations.

EFFECT ON PERMEABILITY

We come now to a consideration of work tending to throw light on the initial means whereby anaesthetics effect their action on plants,—namely, the relation of anaesthesial agents to cell permeability. It is evident that the question of the theory of anaesthesia and the relations of narcotics to cell conditions affecting enzyme action must bear a close relation to this factor. The work of Overton, to be discussed later, may also be classed as studies in cell permeability.

Wächter ('05[a]), in a quantitative study of the exosmosis of reducing and non-reducing sugars in *Allium Cepa* and *Beta vulgaris* in relation to the inhibitory effect of various agents on such osmotic action, found varying effects of ether solutions on subsequent plasmolytic action after a previous treatment with other agents, a concentration of 2 per cent being definitely lethal. Herzog and Hörth ('07) subjected yeast in an evacuated desiccator to vapors of chloroform, ether, alcohol, etc., and noted a rapid liquefaction varying in rapidity with the vapor used. The liquefaction was most rapid with the water-soluble substances, with a descending scale of action to those insoluble in water. The liquefaction was explained as a coagulation of proteins in the cell by the respective vapors, with consequent extrusion of the protein solvents. The rapidity of action, which was the point especially noted, depended of course upon the permeability of

the cell membranes to the respective substances. Chiari ('09) reported that ether, chloroform, and other narcotics increased autolysis of canary's liver, and he ascribed this effect to the solvent action of such substances upon the lipoid constituents of the cell membrane; by such action, he believed, enzymes acting upon cell contents penetrated the membrane more easily. Czapek ('10), in his studies on exosmosis with reference to permeability and surface tension, found that exposure of *Echeveria* cells to chloroform for twenty-four hours produced an alteration in the permeability of the plasma membrane, resulting in the absence of certain precipitation phenomena when treated with caffein. Ether had a similar effect; short periods of narcotization up to one hour had no such action.

Lepeschkin ('11), in a study of the chemical composition of the plasma membrane, showed that substances readily soluble in oil and poorly soluble in water, of the class designated as narcotics by Overton, were held in the dispersion phase of the plasma membrane, and that a proper concentration of such compounds in the aqueous solution bounding the cells may reach a point where resulting electric changes produce a protein coagulation. This in turn affects the selective permeability of the plasma membrane. With smaller concentrations of narcotics in the external medium the chemical composition of the dispersion phase of the membrane would also be changed, so that a certain amount of narcotic would be taken up. Believing that the osmotic properties of membranes must be altered by such action, Lepeschkin ('11[a]) made experiments to determine this point. Aniline dyes, with varying solubility properties in water, chloroform, and ether, were used, and *Spirogyra* cells served as indices of permeability. Etherized algae took up the methyl dyes from aqueous solutions to a lesser degree than the controls. That this action indicated an alteration in membrane permeability was shown by an equal staining of etherized and control filaments previously killed.

Another experiment showed permeability alteration in relation to salts by the isotonic coefficient method, the plasmo-

lyzing solutions being sucrose and potassium nitrate, the indicators epidermal cells of *Tradescantia.* The results showed a consistent reduction of permeability values as the result of narcotic action; increased osmotic pressure was also noted. Ruhland ('08, '12), however, opposes Lepeschkin's findings with respect to basic dyes with the results of his own investigations, accounting for permeability of such substances on other grounds.

Osterhout ('13, '13[a]) studied the permeability of plant tissues by electrical conductivity measurements. In connection with this work he found that anaesthetics decreased the permeability of *Laminaria* tissues. In later studies ('16) he reported that such permeability was reversible, and showed a relation between anaesthetic concentration and the degree of permeability. The relative concentrations for permeability decrease corresponded closely with those effecting anaesthesia. An increase in permeability, on the other hand, was irreversible and caused permanent injury.

Merrill ('15), in an extensive study of exosmosis in response to various factors, found that both chloroform and ether in vapor form and in solution effected a marked exosmosis from the roots of *Pisum sativum,* the first-named anaesthetic having a notably greater action. Lillie ('18) has recently reported experiments with fertilized sea-urchin eggs, which show the direct effect of anaesthetics upon permeability to water.

Harvey ('17) studied the effect of anaesthetics upon the regulation of specific gravity in *Noctiluca,* and also the effect on light production. It was found that such regulatory power was not affected unless the narcotics were used in concentrations sufficient to cause irreversible changes and death of the cells; the animals could be anaesthetized, however, by certain concentrations of ether and chloroform, so that they failed to give the customary flash when subjected to a stimulus. She concluded from her experiments that the anaesthetics affect the mechanism of oxygen utilization in the cell, and not the permeability of the cell membrane for oxygen.

EFFECT ON METABOLISM

As already stated, an adequate survey of the vast field of medical literature dealing with the varied reactions of the animal mechanism to narcotics does not come within the scope of the present paper. The writer here cites only the few investigations relating most closely to plant metabolism studies which have been noted in a search of the literature dealing with the work in plant physiology.

Hegar and Kaltenbach ('70) noted a marked albuminuria following chloroform narcosis in many, but not in all, cases observed. More recently Winterstein ('02) carried out perfusion experiments with frogs to determine the relation of narcotics to metabolic action. On the assumption that there exists a direct connection with nervous response and metabolic function, his data indicate that in ether or chloroform narcosis both assimilation and dissimilation are retarded to the same degree. Failing to accept such an assumption, which, in the light of present knowledge, we are not forced to do, this relationship remains unproved.

Hawk ('04) reported that glycosuria always followed ether anaesthesia in dogs. Baldwin ('05) states that urine following anaesthesia showed higher specific gravity, was more strongly acid in reaction, and showed excretion of acetone, indicating a distinct action of anaesthetics on metabolism. The observations of Ross and McGuigan ('15) showed that the hyperglycaemia following the anaesthetizing of animals was due in greater part to the ether itself and not to asphyxia or excitement. Watanabe ('17) confirmed the glycosuria findings of Hawk by experiments with rabbits.

In the plant field one of the most important studies of metabolic action following anaesthesia has been contributed by Johannsen ('97). Since this work was published in Danish, the inaccessibility of the data to the majority of botanical students warrants a somewhat detailed abstract of the results. The object of the investigation as a whole was to determine the relative influence of anaesthetics upon the metabolism of plants in ripening and resting stages. Preliminary experiments with peas freshly picked and others gathered

some days previously were made to determine the effect of varying amounts of chloroform on the conversion of amido-nitrogen bodies to protein form. In both cases it was evident that such change was inhibited by the anaesthetic, and in proportion to the increase of the concentration employed.

Respiration experiments in all the following studies were made by aspiration of carbon dioxide-free air through the experimental chamber into an absorption apparatus. The absorption liquid was precipitated with a 5 per cent barium chloride solution, and transferred quantitatively to a volumetric flask. After complete precipitation the supernatant liquid was titrated with hydrochloric acid. Nitrogen analyses were made by the Kjeldahl method and sugar determinations by reduction of Fehling's solution.

An attempt was next made in a series of tests to determine if hydrolytic processes were associated with the metabolic condensations characteristic of the ripening process. The materials used were green peas and fresh, green elderberries. The data obtained showed that chloroform narcosis reversed the course of metabolism in ripening seeds; the narcosis not only inhibited to all appearances the elaboration of "amide" nitrogen compounds into proteins, but increased the "amide" nitrogen as well. The condensation or synthesis of the simpler sugars into polysaccharides was also inhibited, with indications of a reversal of the process.

A series of experiments with branches of *Salix acutifolia*, potatoes, and other material showed that with respect to interruption of the rest period the probable predominance of metabolic condensation processes over hydrolytic action could be altered by etherization, and the period of inactivity suspended. These experiments were outlined in detail in another publication of Johannsen and he does not here further consider them.

Etherization of *Salix* buds (in lots of 200) showed a loss in reducing sugar content and a marked gain in nitrogen, as compared with the controls. An analysis of fat, sugar, and nitrogen relations of green lupine seeds following etherization showed a slight increase of all three products directly

after a two days' exposure, with an apparent return to normal fat content and a marked increase of sugar and "amide" nitrogen two days after removal from ether. Another series of experiments with young peas of high sugar content showed a marked gain in "amide" nitrogen content and in reducing power of Fehling's solution, with a reduction in carbon dioxide evolution following a two days' exposure to ether; subsequent aëration for two days showed an increase of the gas evolved, with a slight reduction of sugar and nitrogen values; compared with the controls, the analysis after the aëration showed a distinct increase of sugar and nitrogen products as a result of etherization.

In connection with this work a comparison was made of the "ferment activity" of peas. Seeds freed from their integuments were crushed, dried *in vacuo,* and finely powdered, whereupon the amylolytic action of the powder upon a neutral starch solution (chloroform added as antiseptic) was noted after a period of incubation. The starch was precipitated with alcohol and the supernatant liquid, after filtration and evaporation of chloroform, was examined quantitatively for its reducing power on Fehling's solution. No consideration was given in this series to the possible effect of acid formation upon enzyme activity. According to the values obtained from controls, enzymic activity increased as the sugar content of the seeds decreased; etherization resulted in a marked increase of the values indicating accelerated enzyme action.

In still another experiment the extract obtained from crushed green peas after standing in water was compared with a similar extract heated at an early stage to inhibit enzyme action. Increased inversion values for sugar were notably lower in the control extract. Green peas etherized with varying dosages showed a distinct increase in "amide" nitrogen content with increased concentration of the dose, and the same was true for reducing sugars, although the general effect of ether was again shown to be a tendency towards condensation processes. At the same time, the after-effect of etherization here appeared as an inhibition of the loss of

"amide" compounds. Increased inhibition accompanied greater doses. Similar results are reported to have been obtained with barley and with bulbs of *Crocus*.

For data bearing on the effect of anaesthetics on ripe or resting organs, a series of tests were made on onion bulbs. Etherization for a protracted period had the effect of checking the loss of "amide" nitrogen compounds. *Crocus* bulbs showed a loss in reducing sugars corresponding with the length of exposure to ether; the after-effect indicated sugar accumulation much in excess of the slower increase in control bulbs. Johannsen does not account for sugar decrease during the time of narcosis. A lengthy discussion of the results, very briefly summarized elsewhere ('96), concludes the paper. With respect to protein metabolism, Johannsen considers the alternative possibilities of the action of ether directly upon enzyme action or upon the condensation processes. The theory of the effect of the anaesthetic as a stimulus converting zymogen into an active proteolytic enzyme, —as Green ('87) believed was effected by acids,—is not accepted. To Johannsen the effect upon the condensation processes seems the satisfactory explanation. According to his view, two directly opposing changes take place simultaneously in ripening and resting organs,—a condensation of "amide" substances into proteins, and the reverse. Etherization reduces or stops the first of these processes, so that the second is more effective. The absence of direct proof of this relation is, however, admitted.

For carbohydrates the conclusion is reached that weak dosages accelerated loss of sugar in ripening organs by accelerating condensation processes; medium and strong concentrations retarded and probably inhibited condensation and resulted in the increased sugar content. Where such increase occurred without etherization, the treatment strongly accelerated it. Very strong doses caused a relative reduction of sugar accumulation during and after narcosis. The general after-effect is a reversal of chemical changes, so that hydrolytic action predominates. In many organs this results in the

abolition of the rest period. A strongly increased respiration follows an ether dosage below the injurious or lethal limit.

Czapek ('97) showed that narcotization of the conducting tissues of the petioles inhibits the translocation of the organic food materials from the leaf. Soave ('99) has reported quantitative data showing the effect of ether and of chloroform upon germinating seeds of *Arachis, Cucurbita, Hordeum, Zea,* and *Pisum,* with special reference to respiration and to the metabolism of fats and proteins. He concluded that anaesthetics inhibited anabolism without suspending catabolic processes. Zaleski ('00) made a study of the changes exerted by ether on the protein content of etiolated seedlings of *Lupinus angustifolius.* From the analyses made it was concluded that in an ether atmosphere proteolysis is retarded. Other experiments with wheat seedlings indicated that ether checks loss of glucose and induces a greater transport of this sugar from the endosperm to the plant.

Further studies of the effect of etherization on the relative amounts of nitrogen compounds in the axial parts and in the cotyledons led him to conclude that in an ether atmosphere more proteins either collect in the axes, or else are there formed,—which would argue for a stimulus of protein synthesis. Zaleski's data are in some cases open to criticism, in so far as some of the values from which he drew conclusions differ by amounts within the range of experimental error. His conclusions regarding protein translocation have also been disputed by Hempel ('11) as based on insufficient evidence.

In the study of tyrosin formation in roots of *Lupinus albus* seedlings, Bertel ('02) found that crystal formation could be induced by stimulation with chloroform, ether, and other volatile organic compounds. A narcosis of 24 hours resulted in a loss of tyrosin, which disappeared entirely at the end of 3–4 days. Since these results were obtained under aseptic conditions, Bertel ascribed them to an enzyme autolysis incited by the anaesthetic. In support of this view he stated that coincident with the loss of tyrosin was the presence in

the roots of a substance which reduced ammoniacal silver nitrate solution much more actively than did the controls.

Another extensive study of the metabolic processes following etherization has been made by Hempel ('11), using seeds and seedlings of *Pisum* and *Lupinus*, buds of *Acer pseudoplatanus*, and injured potato tubers. The data reported were of a quantitative chemical nature. From a considerable amount of analytical work the following conclusions were reached:

Protein hydrolysis with simultaneous formation of "amide" compounds, occurring normally during seed germination, was retarded by narcosis in proportion to the dosage used. Very small doses produced acceleration. The after-effect of small doses was an acceleration of catabolic processes; for large doses, a retardation.

Sugar formation (estimated as glucose) was accelerated by a small or moderate dosage of short duration. Longer exposure to the same concentrations effected a retardation.

The translocation of nitrogen compounds to the shoots may possibly be affected by etherization, since a relation appears to exist between their increase and the protein hydrolysis in the cotyledons.

Etherization of buds (*Acer pseudoplatanus*) with small doses produced an increased quantity of "amides," either in light or in darkness. Larger dosage retarded protein synthesis.

A condensation process of considerable duration involving nitrogen compounds characterizes wounding of potato tubers; such condensation appeared to be retarded by moderate ether doses. A long exposure to the ether (3 days) effected a retardation of 2 days. Large dosages inhibited the formation of "wound cork."

Hempel divides ether narcosis into three phases:

1. The excitation phase resulting from short exposure to small doses. The usual effect is acceleration of metabolism.

2. Narcosis proper, resulting from short exposure to large doses or long exposure to small ones. The usual effect is

retardation of metabolic and dependent processes, such as growth and germination.

3. The toxic phase, resulting from prolonged exposure to large doses.

EFFECT ON ENZYME ACTION

The preceding topic has considered the effect of etherization on the metabolic processes induced by enzyme action. Another phase of the subject that has engaged the attention of investigators is the direct effect of narcotics upon the catalytic agent as studied in the laboratory. Müntz ('75) erroneously attempted to distinguish between organic and inorganic fermentation phenomena by a difference in their behavior with respect to chloroform,—the latter inhibiting organic but not inorganic fermentation (". . . sans influence sur les fermentations d'ordre chimique''). Several decades later Detmer ('81) published a study of the effect of various substances on plant cells and their ferments; diastase action was studied in relation to its inhibition by various concentrations of solutions. Chloroformed seedlings were killed without inhibition of diastatic activity. In relation to the effect of external agents on enzyme action Detmer postulated four possible conditions:

1. Neither cell life nor enzyme activity is affected.
2. Cells may be killed and enzyme activity inhibited.
3. Cells may be killed and enzyme activity continued.
4. Cells may not be killed and enzyme activity inhibited.

His results led him to the conclusion that chloroform, among other substances, affected the protoplasm without bringing a direct chemical factor into play.

Bertels ('92) reported that preparations of commercial pepsin suffered injury when subjected to the action of chloroform, while digestive extracts from freshly prepared mucosa of the pig's stomach showed no such effect. Ether and chloroform, according to Fermi and Pernossi ('94), had different effects on trypsin and pepsin preparations; in chloroform they withstood a temperature of 80 degrees for 1 hour, while in ether they suffered injury. Lintner and

Kröber ('95) noted a marked retardation of enzyme activity when chloroform was added to a mixture of maltose solution and yeast extract, less dextrose resulting in the same intervals from the etherized mixtures than from the controls.

The studies of Puriewitsch ('97) were primarily concerned with the translocation of reserve food with relation to factors regulating osmotic action, but in connection therewith he noted that the presence of ether or chloroform caused inhibition of reserve-stuff movement, such movement being directly dependent on enzyme activity.

Kaufmann ('03) found that trypsin solutions at concentrations greater than 2 per cent were not injured by a 24-hour action of chloroform or toluol, while weaker ones were affected, as shown by action on gelatin and on albumin and by decrease in enzyme concentration. Grober ('04) reported the injurious action of toluol and chloroform upon the enzymes in urine. Among several factors of environment and chemical content influencing the diastatic action in higher plants Eisenberg ('07) found that ether exerted a considerable influence. Doses of 1–2 cc. per 3½ liters volume exerted an injurious action on the enzyme, and all concentrations used showed inhibitory effect. Butkewitsch ('08) noted that toluol and chloroform induced starch hydrolysis in bark and cortical tissues of twigs of *Morus alba* and *Sophora japonica*. Both the bark and an aqueous extract thereof inverted maltose, but an alcoholic extract did not. The effect of the antiseptics is regarded as analogous to that of low temperature in reducing the activity of a starch-synthesizing enzyme.

Carlson and Ryan ('08) showed that increase of diastatic concentration in the saliva of the cat resulted from general ether anaesthesia, while Carlson and Luckhardt ('08) found under like conditions there resulted a slight decrease in the blood diastase of animals. Apsit and Gain ('09) reported that wheat seedlings killed by sulphuric ether retained their diastatic activities. Müller-Thurgau and Schneider-Orelli ('10) ascribed to ether but little action on the processes concerned in the conversion of sugar in stored potatoes. Howard, in his periodicity studies already referred

to ('15c), attempted to collect data upon the effect of etherization on the enzymic activities of his material, with respect to diastatic, proteolytic, lipolytic, and oxidative action. His results, however, were all of a general and qualitative nature, no chemically quantitative data being presented. In line with Carlson, Ross and McGuigan ('15) showed that ether anaesthesia does not increase the diastatic power of the blood serum. Watanabe ('17) found the diastase of rabbit's blood to remain practically constant except for a slight tendency to increase immediately after the anaesthesia. Burge ('17) noted that the catalase content of the blood decreased during ether administration and increased during recovery from the anaesthetic. The decrease, he believed, may be the cause of decreased oxidation during anaesthesia. Catalase action was destroyed *in vitro* by exposure to ether vapor, as during *in vivo* conditions. In such case it was not restored to normal amount when the ether was removed by bubbling air or oxygen through the blood, as occurred *in vivo*.

EFFECT ON CHEMICAL REACTIONS

The effect of anaesthetics on chemical reactions can hardly be considered as a phase of the present subject distinct from permeability or metabolic response. It will, nevertheless, be so reviewed here because of the striking and apparently direct relation between the chemical products noted and the anaesthesial stimulus to enzyme action.

Mirande ('09) was the first to report the very quick response of the leaves of *Prunus Laurocerasus* to the action of ether and other stimuli by liberation of hydrocyanic acid. This reaction was indicated by the sodium picrate paper test. Plants of several other genera responded in a similar manner. Guignard ('09) followed this work with an account which showed that the chemical reactions involved the hydrolysis of a cyanogenetic glucoside, which hydrolysis is effected by an alteration of cell permeability.

Vinson ('09), in a preliminary note, indicated that the fruit of the date palm when subjected to the vapor of acetic

acid for 12–15 hours underwent a marked acceleration of the ripening process. Waller ('10) concluded after a quantitative colorimetric study of the Mirande-Guignard hydrocyanic acid phenomenon that the evolution of the acid, in relation to electrical response as an index of life, was a post-mortem result. This, in view of the rapidity with which acid production has been noted, argues for an extremely rapid action of the anaesthetic on permeability. In later papers Vinson ('10, '10[a]) showed that the fore-mentioned forced ripening of dates could be effected by a great variety of substances, volatile and liquid. In general, the more volatile the substance the quicker the action. It appeared from the results that the chemical structure of the stimulants was not a factor, but that the stimulus was due to the killing of the protoplasm by penetration of the stimulant, with consequent release of previously insoluble intracellular enzymes. This explanation was supported by heating dates to varying degrees. A temperature that killed the cellular protoplasm without injuring the enzymes effected ripening. That ripening depended upon the enzyme relation or condition appeared evident from the fact that, despite the presence of considerable invertase, the sucrose of green dates was very slowly inverted; if, however, the fruit cells were crushed by grinding, rapid inversion resulted. It is believed that by the death of the protoplasm by toxic, thermal, or mechanical means, ripening is facilitated by the conversion into soluble form of an enzyme previously held in insoluble condition by the living protoplasm.

Heckel ('09) reported the action of anaesthetics in rapidly liberating cumarin from leaves of *Liatris spicata, Angraecum,* and other plants, and melilotol from *Melilotus officinalis,* the phenomena being accompanied by plasmolytic changes. In a later communication ('10) he announced that chloroform and ether both accelerated vanillin formation in *Vanilla planifolia* by causing excretion of water and hastening the drying process.

Results of a most striking nature with special bearing on the writer's problem have been announced by Willaman ('17), who studied the effect of anaesthetics upon the cyanogenetic

content of *Sorghum vulgare*. He was able to show an increased yield of hydrocyanic acid, both glucosidic and non-glucosidic, from leaves exposed to chloroform and ether vapors. This would indicate a stimulation of both hydrolytic and synthetic enzymes and is regarded by Willaman as a demonstration of enzyme synthesis *in vivo*. In this connection he also reported that the enzyme powder extracted from chloroformed leaves was 25 times as active towards an amygdalin substrate as the enzyme from controls.

STIMULATION, INHIBITION, AND THE THEORY OF NARCOSIS[1]

Any consideration of the theory of narcosis or any attempt to explain the nature of stimulation involves a discussion of the structure of the plasma membrane and the theories of its composition and permeability.

Probably the first theory of anaesthesia was that essayed by Claude Bernard ('78), who distinguished between anaesthetics and narcotics, a distinction which, in the light of present knowledge, is no longer accepted. As anaesthetics he classified substances such as chloroform and ether which acted on both plants and animals and whose action was temporary. Under narcotics he grouped those which did not affect all protoplasts but only nerve ganglia. The present understanding of stimulation and toxic action of substances in the light of their physico-chemical behavior no longer regards any distinction between narcotics and anaesthetics. Largely on the basis of his study of the effect of anaesthetics on nerve tissues, Bernard regarded anaesthesia as the result of a coagulation of the protoplasm, with the resumption of normal conditions by elimination of the poison from the tissue.

Dubois ('83) advanced another theory,—that of dehydration of the tissues by anaesthetics,—as the result of his experiments with plants, and Verworn ('00) considered the action to be due to an inhibition of processes dependent upon the presence of oxygen. This theory has not been universally accepted, and the work of some investigators tends to show

[1] For an excellent discussion of this subject and of the related literature see Lillie ('16).

that it is untenable. Thus, Loeb and Wasteneys ('13, '13[a]) have reported that chloroform, among other narcotics, produced complete narcosis in fertilized eggs of the sea-urchin, without practically lowering the rate of oxidation; similar results were obtained with fish embryos and with medusae.

Modern theories of narcosis, based on studies of membrane permeability, structure, and composition, have been expounded since the well-known work of Overton ('95). This investigator published data on the osmotic properties of plant and animal cells, in which he adduced evidence to show that although the permeability of solutions towards protoplasm decreased with their specific gravity, the size of the molecule was not the sole conditioning factor. This work was the forerunner of his study of narcotics ('01) in which he reached conclusions previously arrived at independently by Meyer ('99) and which form the basis for the much-disputed Meyer-Overton theory of narcosis. According thereto the conclusions are:

1. All chemically "indifferent" compounds which are lipoid solvents act as narcotics on protoplasm wherever they come into intimate contact therewith.

2. Action is effected first and most strongly in cells in whose chemical composition lipoids predominate,—hence especially in nerve cells.

3. The relative effectiveness of such narcotics is dependent upon their mechanical affinity for lipoids, on the one hand, and for the other cell constituents, especially water, on the other. It is determined in a mixture of water-soluble and lipoid constituents upon the partition coefficient; i. e., the effect varies directly with increase in lipoid solubility.

Lepeschkin ('11) essayed to throw light on the chemical nature of the plasma membrane and of the dispersion medium of the outer protoplasmic layers, wherein he considered osmotic selective power to reside. This he attempted by a comparison of permeability changes. Comparisons were made of the concentrations of various solutions sufficient for albumin coagulation with those necessary for the complete coagulation of membranes of *Tradescantia, Spirogyra,* and

Saccharomyces cerevisiae. Coagulation temperature limits of the membranes were noted and compared with those of proteins. A determination of albumin coagulation concentrations for lipoid solvents, as ether, chloroform, etc., showed that they were much greater than those acting on the plasma membrane. The concentrations appeared to correlate with the partition coefficients in water and oil. The general conclusion was reached that proteins or loose protein combinations are important constituents of the plasma membrane, and that bodies of a lipoid nature are also present; whether the latter are lecithin or cholesterin compounds, as Overton has suggested, or merely fat bodies, was not concluded. Data harmonizing with the Overton hypothesis have been published by Zehl ('08), who studied the action of varying temperatures in relation to the toxic action of a diversity of poisons upon two fungi. The noteworthy results with respect to the present discussion were the marked reductions in toxicity of the common anaesthetics for both *Aspergillus* and *Penicillium* with rise in temperature, the limiting toxic concentrations of both chloroform and ether being notably increased. Such action, Zehl has pointed out, accords with reduction of the partition coefficients and threshold concentrations of narcotics with increase of temperature, as shown by Overton.

Choquard ('13), from a study of muscular response of tissues with scant and abundant lipoid content to treatment with narcotics, found the Overton theory insufficient explanation for the results obtained. Rapidity of narcotic penetration appeared to be an important factor involved. Another type of experimental data is that of Alexander and Cserna ('13) who studied the gas exchange of the brain in ether narcosis as compared with the narcosis produced by non-lipoid solvents. The values of the carbon dioxide production and oxygen evolution associated with the respective kind of anaesthesia are the grounds on which these workers take exception to the Overton theory as an explanation. They incline to a view more in harmony with that of Mansfeld ('09). Osterhout ('13[a]) also opposes the Overton view with the results of his experiments on plasmolysis of *Spirogyra* with

solutions of inorganic salts. Traube ('13) regards lipoid solubility as an accompanying phenomenon, and not the cause of narcotic action. According to his theory, the action of anaesthetics is caused not by their solution in the cell lipoids, but by adsorption and surface-condensation of these substances at physiologically active surfaces; such surfaces may be of lipoid or protein nature. The action of narcotics, according to this view, is due to a lowering of the surface-tension rather than to lipoid solubility, such tension changes affecting the degree of adsorption and hence of narcotic action.

Lillie ('09, '09[a], '09[b], '11, '12, '12[a], '13, '13[a], '13[b], '14, '16, '18) has devoted much attention to the effect of anaesthetics on the plasma membrane, working especially on the larvae of *Arenicola* and eggs of *Arbacia*. These contain a pigment, which, under proper osmotic conditions, passes into the surrounding medium. Proper solutions of electrolytes thus caused exosmosis, but the addition of certain narcotics to the same concentrations inhibited such action to varying degrees. In general, all anaesthetics were markedly injurious in strong concentrations, while in weaker ones they showed a protective action against the electrolyte. According to Lillie the solubility relations between the lipoids of the membrane and the narcotics result in a reduction of permeability produced by increase in volume of the lipoid particles. The essential effect, according to Lillie, is a modification by narcotics of the physical properties of the plasma membrane of such nature that the latter, under the usual conditions of stimulation, fails to undergo the increase of permeability essential to such stimulus. A real stimulation must therefore involve a well-defined increase of membrane permeability.

The outstanding feature of the literature here surveyed is the variation in the effect produced by the same narcotic agent. Whatever the manifestation of activity in plant or animal that has been studied, the consensus of results points to a condition of stimulation, inhibition, injury, or death, varying with the concentration used or the length of exposure. The theory advanced by Lillie appears to furnish an explana-

tion for such different reactions. The permeability changes in the plasma membrane produced by narcotics involve differences in ion concentration on the two sides of the membrane, with resulting differences in electrical potential. It may be assumed that the cations concerned in the production of this potential are the ions derived from dissociation of carbonic and other weak acids produced in metabolism, and that carbonic acid is the chief electrolyte concerned in the production of this potential. In other words, the plasma membrane of the resting cell may be regarded as the seat of a potential difference and is electrically polarized in such a way that the solution in contact with its outer face is positive with respect to the enclosed protoplasm and that during stimulation this potential difference increases. If this Nernst theory of cell polarization is accepted, any increase in the ionic permeability of the membrane produces a corresponding change in its polarization; the phenomena involved in such electrical changes are hence primarily responsible for stimulation.

Lillie points out that the most evident chemical effect of muscle stimulation is increased carbon dioxide production, and his explanation of this increase,—which may be applied to plant tissues,—is that it is due to the increased permeability of stimulation. Chemical equilibrium, it is recognized, depends upon equalization in velocity of the opposite pairs of chemical reactions. If the reaction products of one side of the equation are removed, acceleration results. If such products are slowly but continuously removed the relative velocity of the reaction producing them will depend upon the rate of such removal; any increase in this rate of removal from a system of interacting compounds in an approximate equilibrium will result in a corresponding acceleration of the process in the direction of the removed substance.

Now, according to Lillie's view, carbon dioxide is the reaction product whose rate of removal from the cell determines the velocity of the chemical processes concerned in stimulation. Normally the rate of removal is controlled by the degree of permeability of the plasma membrane. A slight in-

crease in the permeability, induced by the solvent action of an anaesthetic on the membrane lipoids, produces stimulation; an increased amount of such lipoid solvent makes a change in membrane permeability difficult, with resulting inhibition or narcosis. A still greater amount injures the membrane, causing irreversible cell changes and consequent death.

THEORY OF ANAESTHETIC ACTION ON ENZYMES

A consideration of the possible mode of action of anaesthetic substances upon enzymes seems desirable, inasmuch as such action involves the effect upon the catalytic agents of cell metabolism, as distinct from the direct effect upon plasma permeability. Palladin ('10), in a paper already noted, pointed out four possibilities in his study of respiratory enzymes. Regarding this group of catalysts these possibilities are:

1. Direct effect on one or all respiratory enzymes.
    a. Stimulation as a catalyser.
    b. Inhibition as an anti-ferment or toxin.
2. Effect on reactions which precede enzyme formation.
    a. Stimulation by conversion of zymogens to enzymes.
    b. Inhibition by killing of zymogens.
3. Effect on reactions which furnish material for respiration (i. e., for cleavage and oxidation).
    a. Stimulation as catalysers for proteolytic and glucosidic enzymes.
    b. Inhibition as an anti-ferment or toxin.
4. Effect on the environment of the enzyme, with resulting increase or decrease of enzyme activity.

Palladin's experiments led him to the general conclusion that respiratory stimulation depended on the increased conversion of zymogens to enzymes. Such increase, however, he considered, was accompanied by increased enzyme destruction, by which explanation he accounted for the equal amounts of enzyme in control and in dead plants.

Armstrong and Armstrong ('10) reported studies on hydrolysis of the glucoside prulaurasin in the cherry laurel, which were inspired by the earlier reports of Mirande ('09)

and Guignard ('09). The stimulative action of various volatile substances was noted, as well as the effect of solutions of electrolytes and non-electrolytes. Observations showed that all substances which were able to penetrate the cell membrane acted as stimulants to varying degrees. The most active stimulants were those with little, if any, chemical activity, and which have very slight attraction for water,—i. e., they are anhydrophilic. It was also shown that hydrogen cyanide or benzaldehyde,—two of the products of prulaurasin hydrolysis,—had a cyanogenetic effect upon the leaves similar to that of the other vapors studied; hence the Armstrongs concluded that the action of the penetrating substances could not be primarily a chemical one, since it could be effected by some of the products resulting from the hydrolysis itself. The stimulation produced by chemically inactive vapors is ascribed to their action in causing changes in the concentration of the cell solution of such nature that the glucoside and the enzyme are brought into contact under conditions which promote hydrolysis. All substances which enter the cell effect such concentration changes to some degree. In the case of substances in solution the water entering with the solute is probably a factor in altering the concentration of the cell fluids. It is evident that this theory is based upon the assumption of a purely "mechanical" activity on the part of the stimulating agents, as a result of which the concentration is lowered to a point which is either favorable to a change previously existing only in a potential state, or is more favorable to an action already occurring.

The effect of the same stimulating substance acting as a narcotic or lethal agent is ascribed to changes in the osmotic pressure. Assuming an active cell, the pressure varies continually as carbon dioxide and other simple compounds are removed from solution and combined in more complex forms. With their disappearance others diffuse in from without. The more complex molecules are in part more or less inactive by incorporation in the protoplasmic mass, but some have a marked attraction for water. The products of the "downgrade" changes which occur at the time of synthetic trans-

formations are also hydrophilous. The result is that the water in the cells is in a constant state of dissociation between the form $(H_2O)_x \rightleftharpoons X(H_2O)$. Protoplasmic movement and the associated changes in cell contents are probably dependent on the exchanges occurring between the "hydrolated" colloid surfaces and the solution. The action of the anaesthetic in increased concentrations is believed to cause stoppage of movement by increased osmotic tension, which produces a balance of the attraction between the protoplasm and the solution. In a later communication ('11) these authors point out the applicability of Starling's name of hormones, or excitants of functional activity to the anhydrophylic stimulants above noted, which pass through differential septa.

From a general consideration of the foregoing survey of literature it is clear that the investigations on plants group themselves into three fairly distinct classes. In the first class are all those concerned with streaming, tropisms, germination, growth, transpiration, respiration, etc., in which the activity noted, whether physical or chemical in nature, may be regarded as the "end product" of the etherization stimulus. In the second group are the studies dealing with the more immediate effect upon metabolism proper. The third comprises those relating to the effect on membrane permeability, upon which all the other phenomena undoubtedly depend.

For the moment we are more especially concerned with the metabolism experiments. These have been of great interest and value, not only for the light which they throw upon the chemical processes going on within the plant at different stages of its life, but also for the impetus they furnish to pursue further the question of enzyme relation to stimulation phenomena.

If it be granted that the activities studied in experiments of the first group,—those of ultimate response,—are primarily dependent upon the fundamental metabolic processes within the plant, we are led to one of two conclusions: (1) The effect of narcotics is one solely concerned with membrane permeability. All subsequent effects on metabolism are the indirect results of such permeability changes. (2) The effect

of narcotics may be one directly involving the activation or inhibition of the enzymes of metabolism.

In either case the effect of anaesthetics upon enzyme action is deserving of study. For if the second hypothesis be discarded at once, there still remains the very evident possibility that the permeability changes induced in the membranes by narcotics (and such changes are established facts) may, by altering the conditions of concentration within the cell, produce changes in the chemical condition or activity of the enzymes.

Johannsen ('97) does not regard the conversion of proenzymes or zymogens to active forms as a plausible explanation of his metabolism studies, and although he admits the possibility of increased enzyme activity following stimulation, he believes it doubtful. His explanation lays all the emphasis upon the condensation processes and their reversal. We cannot, however, escape the fact that, so far as we know, enzymes are responsible for such syntheses and hydrolyses; therefore they have either been incited to action or inhibited by concentration changes, or else they have been directly acted upon,—converted from inactive to active form,—or the reverse.

On the other hand, as we have noted, Palladin ('10) in his studies of respiration enzymes not only considers the stimulation or inhibition of existing enzymes, or the conversion of zymogens to active forms (or the reverse) as possible, but actually concludes from his experiments that respiratory stimulation depends upon increased zymogen conversion. In addition we have the very striking results of Willaman ('17) which indicate the possibility of enzyme synthesis *in vivo* and the still more remarkable increase in the activity of an extracted plant enzyme as the result of narcotization.

In view of the contrasting viewpoints, it has seemed desirable to attempt to secure additional data bearing on these points by studying the effect of ether upon plant enzymes, as measured by their action upon various substrates under control conditions, using quantitative chemical methods.

It must, of course, be here emphasized that such data cannot in themselves be considered as quantitative. The difficulties and errors involved in the methods and procedure of enzyme extraction under the most favorable conditions preclude the consideration of resulting data as other than comparative. With this limitation, however, they should, whether of positive or negative nature, nevertheless prove of interest.

Methods and Materials

For the control of temperature conditions a large constant temperature water bath of 85 liters capacity was devised. Details of construction of the apparatus will be reserved for future publication. It will suffice to say that the water container was a rectangular galvanized iron tank 112 cm. long, 36 cm. wide, and 41 cm. deep, insulated with solidly packed excelsior. The reservoir permitted the use of two parallel rows of six two-quart glass Mason jars which served as containers of the material studied. Heat maintenance and control were electrical. Uniformity of temperature in the bath was insured by two electrically driven paddles of the propeller type. An indicator arm with pen attached, similar to the recorder of a Friez thermograph, was connected with the heat-controlling device and registered temperature deviations on the dial of a clockwork recorder. With preliminary trial and adjustment it was found possible to maintain a desired temperature within $\frac{1}{4}$–$\frac{1}{2}$° C.

The plant material studied was in all cases brushed and washed in tap water, disinfected by immersion for two or more hours in a 0.1 per cent solution of mercuric bichloride, washed for several hours in running water, and finally dipped in two changes of distilled water and one of 70 per cent alcohol, when it was turned out on clean absorbent paper and when dry placed in the jars. Each lot was weighed and transferred to a numbered cheese-cloth bag before disinfection, thus reducing handling to a minimum.

At the beginning of an experiment the control portions and those to be etherized were placed in the water bath at the

desired temperature and subjected to a preliminary heating for 24 hours to insure a uniform heat throughout the tissues. The jars to be etherized were then fitted tightly with rubber stoppers, through each of which passed a piece of glass tubing of about 5 mm. diameter and 8 cm. in length. The upper end of this tube was fitted with rubber tubing and a screw clamp. From the part below the stopper a small basket of copper gauze containing a tuft of cotton was suspended by copper wires. Before etherization the stoppers were forced in as tightly as possible, and the juncture of stopper and jar, as well as the surface of the former where the tube entered, was thoroughly sealed with a liquid mixture of equal parts of beeswax and paraffin. The calculated ether dose was dropped with a pipette through the tube on the cotton below, and the screw clamp immediately and very securely tightened. That no ether escaped during the experiment, even with the pressure resulting from the temperatures used, was evident upon opening the clamp at the end of the exposure. The control jars were also fitted with rubber stoppers, but were not sealed. In every case the dosage used per jar was 1 cc. of Merck's ether for anaesthesia. Johannsen ('06) in his forcing experiments recommends 0.4 gm. per liter volume, and the amount used in the following work approximates this very closely on the basis of 1800 cc. volume per jar.

Upon removal from the jars at the close of this part of an experiment, the plant extracts, whether studied as such or used for enzyme extraction, were made in the following manner: The bulbs or corms were rapidly grated on a fine-meshed, flat grater into a large porcelain dish and transferred in a manner as nearly quantitative as possible with a minimum amount of distilled water to water-tight, tin cylinders 15 cm. high and 6.5 cm. in diameter, with tightly fitting covers, which were at once placed in a freezing mixture of ice and salt. At the end of a sufficient time the frozen cylindrical mass was removed from each tin and again grated. The resulting mass of snow was then transferred to large glass jars for extraction. In the case of the preliminary experiments with tulips, where the extracts were studied directly, extraction was made

by addition of distilled water to a volume of 750 cc., and the liquid finally obtained after straining and filtering through a Buchner funnel made up to 1 liter, plus 1 per cent toluol as antiseptic.

In the preparation of the enzyme powder the melted mass was extracted for 18 hours with three times its volume of distilled water, plus 1 per cent chloroform, after which it was strained and then filtered through a Buchner funnel. The solid residue was ground for 20 minutes with an equal volume of fine quartz sand and further extracted for 24 hours with 2 volumes of water, after which it was likewise strained under pressure and filtered. The final solutions thus obtained were of a heavy colloidal nature. By this freezing and grating method, with subsequent grinding and secondary extraction, it is believed that the plant cells are thoroughly ruptured and that the extraction is likely to be as complete as it is possible to make it without special apparatus for comminution and pressure. The tissue pulp after grinding showed under the microscope a very thorough disruption of the cells. The colloidal nature of the solutions made their filtration under pressure a slow process, so that during it, as well as during the time necessary for the later filtration of the enzyme precipitate, all solutions were preserved with 1 per cent toluol.

Precipitation of the enzyme-protein complex was effected with 95 per cent alcohol, in the proportion of three volumes alcohol to one of plant extract. The precipitate obtained after treatment for fifteen minutes was collected under pressure upon filter paper, and quickly dried with an electric fan at room temperature, after which the papers were stored in glass-stoppered bottles for future use. Later in dissolving the dry enzyme material it was found that the greater portion on each filter was easily removed by moistening it and scraping the surface with a safety razor blade. A moist chamber or any vessel with a flat bottom was found satisfactory for the work. The residue on the filters was obtained after trituration in a mortar, by solution in water, and straining through cloth.

Experimental

A preliminary experiment was made with tulip bulbs for the purpose of obtaining data on optimum conditions of temperature and exposure with respect to etherization. The bulbs were freed of their papery integuments without injury to the scales and etherized after disinfection, as already outlined. In one series a temperature of 25°C. was maintained and in the other 35°C. At each temperature exposures to ether of 12, 24, and 36 hours were made, with corresponding controls. The method of obtaining the plant extracts for the analyses has already been stated. After extraction the solutions were heated as rapidly as possible to 90°C. in the hope of inhibiting further action of enzymes present and, upon cooling, made up to liter volume. Analyses of aliquot parts were then made for content of glucose, sucrose, and maltose, using the modified Bertrand method of Shaffer ('14). For the maltose determinations hydrolysis was effected with 5 cc. concentrated hydrochloric acid plus 50 cc. distilled water per 20 cc. extract. All portions were simultaneously heated for 1½ hours at 100° C. in an Arnold sterilizer, after which they were neutralized to phenolphthalein with 20 per cent sodium hydroxide and made up to 100 cc. volume. Ten-cc. portions were then taken for sugar determinations.

In making determinations of sucrose content based upon invert sugar values, a modification of the order of procedure in the Shaffer method was necessary. It was found that if inversion were attempted with 10 per cent citric acid, as suggested by Davis and Daish ('13), and the Shaffer method then used, that it was impossible to centrifuge out the colloids precipitated by addition of the dialyzed iron. It is possible that this is due to a solution of the iron in some citrate combination analogous to solution of copper in Fehling's solution. To avoid this difficulty, the proteins were first precipitated from equal portions of each solution by the same method and then inverted with citric acid by exposure to boiling temperature in the Arnold sterilizer for 15 minutes. The usual neutralization with alkali and increase to standard volume followed, after which the balance of the Shaffer method was continued,

with due allowance in the final computations for the difference in concentration of sample.

The numerical values of the resulting sugar determinations are not presented, for the reason that they show quite convincingly that the carbohydrate enzymes were not inactivated by heating to 90° C. The maltase values, for example, showed a content of that sugar which ranged from 14 to 41 per cent of the fresh weight of the bulbs. The findings for sucrose showed no such disproportionate values, neither did they afford any data bearing on optimum conditions of temperature or length of etherization. The only point of value that appeared was the fact that the sugar in the bulbs was not present to any extent in the form of glucose, but probably all as maltose. The very great sugar formation must be ascribed to a continued action of the carbohydrases following the heating to 90° C. until the time of analysis. This period, which involved the time necessary for completing one of the series and the subsequent extraction process, was of considerable extent.

It would appear from these results that the accurate determination of sugar values or analyses of similar nature from solutions thus obtained are not practicable, since a temperature sufficiently great to inactivate the enzymes present would, in the time necessary for its application, undoubtedly affect other hydrolytic changes in the presence of organic acids which would also introduce a large factor of error. Apparently the only satisfactory means of dealing with plant extracts for analytic purposes is that of alcohol extraction *in vacuo* similar to that described by Davis and Daish ('13, '16). In the absence of any definite conclusions from these preliminary trials, it was decided to use the mean conditions of temperature and time of etherization in the experiments in which the extracted enzymes were to be tested. Accordingly the temperature used was 30° C. and the exposure to ether 24 hours. The experiment was divided into two sections; in the first the material was extracted immediately at the close of the etherization period and in the second it was aired for 18 hours after etherization and then extracted.

For this study corms of a hybrid *Gladiolus* (*G. gandavensis* × *G. psittacinus*) were used. These were stripped of their coarse outer scales and the basal parts carefully scraped clean, without injury to the living tissues. They were sorted for uniformity of size and condition and divided into four lots of 20 corms each. There was no evidence that the corms had started active growth, but it may be assumed that at the time they were in the last stages of the resting period. The weights of the several lots and their treatment follow:

Lot	No. of corms	Weight in gms.	Treatment
A	20	403.2	Etherized for 24 hours and extracted.
B	20	403.2	Control.
C	20	402.9	Etherized for 24 hours and aired for 18 hours before extraction.
D	20	401.8	Control.

Two smaller lots, C and D, of 11 corms each, weighing respectively 191.7 gms. and 194.3 gms. were also sorted at this time, and after disinfection placed in cold storage for future experiments on catalase action.

The following substrates were used for a determination of the action of the respective enzymes:

Starch (Merck) Dextrin (Merck)	for amylases
Sucrose (A. Daigger & Co., h. p.) Maltose (Merck) Inulin (Merck)	for sucrases
Ethyl acetate (Sargent & Co., c. p.) Ethyl butyrate (Sargent & Co., c. p.) Olive oil (Merck) as emulsion	for lipases
Asparagin (Merck) Acetamid (Merck)	for amidases
Albumin (Merck) Casein (Baker) Peptone (Bacto-peptone) Albumin (Merck) in digestion tubes	for proteases

The substrates were all made up in 1 per cent aqueous solutions with the exception of the starch solution and the olive oil emulsion. Casein was dissolved in sodium hydrate and then made up to volume with water. The preparation of the starch and oil substrates has been outlined by Zeller ('16), but the details are here repeated for those to whom his paper may not be accessible.

Five grams of soluble starch were added to 300 cc. of distilled water and while constantly stirred brought to boiling. This was added to a flask of two liters capacity containing 1200 cc. of hot distilled water, and the contents then boiled with a reflux condenser for 2 hours; when cool the solution was made up to 2 liters, plus 1 per cent toluol as antiseptic. The above constitutes what is known as a $\frac{1}{4}$ per cent solution.

The method for making the olive oil emulsion is one which Davis ('15) and Zeller ('16) ascribe to Bloor, but the writer has been able to find no description of it by the latter in the literature, and it is therefore taken from the sources indicated. The procedure was as follows: Twenty cc. olive oil were dissolved in hot absolute alcohol. This was placed in a hot funnel, the tip of which had been drawn out to a very fine bore, and the hot solution of oil in alcohol passed drop by drop into 200 cc. of cold distilled water which was vigorously stirred throughout the process. The resulting milky emulsion was then boiled to expel the alcohol and upon cooling made up to 1 liter with distilled water.

The extracted enzymes of the first series (lots A and B) were dispersed in such a volume of doubly distilled water that 0.8 cc. of solution represented 1 gm. of fresh tissue. In the second series (lots C and D), loss by accident of one-half the dispersion just previous to use necessitated its dilution to half the strength of that in the first series. Ten cc. of dispersion in each case were added to 50 cc. of substrate in Erlenmeyer flasks of 125 cc. capacity, with 0.5 cc. toluol as antiseptic. For controls 10 cc. of distilled water per flask of substrate were substituted for the volume of enzyme. Comparison was also made between active and inactivated enzymes by a parallel series of substrate flasks containing equal

volumes of the enzyme dispersion previously autoclaved at a pressure of 15 pounds.

The sucrose substrate was acidified with 0.1 cc. of decinormal hydrochloric acid, since invertase is known to act best in acid medium. The solutions of albumin, casein, and peptone were made neutral, and for the alkaline series of these substrates 2 cc. decinormal sodium hydrate added to each flask, with an equal volume of water to the neutral ones. The digestion tubes were made by coagulation in hot water of a 10 per cent aqueous solution of albumin in glass tubing of 2 mm. diameter. These tubes were placed in 50 cc. of distilled water plus 0.5 cc. toluol, and 2 cc. decinormal hydrochloric acid or sodium hydrate added to the acid and alkaline series respectively. All flasks were placed in the incubator and maintained at 40–41° C. throughout the several periods of incubation. At the close of such periods they were placed in the autoclave, subjected to 15 pounds pressure for a few minutes, and upon cooling were used in the quantitative determinations hereinafter discussed.

The period of incubation varied with the substrate studied. The time for checking enzyme action was approximately determined by the use of trial flasks of substrate with enzyme extract from the etherized series. Such flasks were used only for the carbohydrates. In the case of starch, drops from the trial flask were tested on a spot-plate with iodine solution at intervals after the beginning of incubation until the end point appeared to be approaching; at this point the flasks were autoclaved. For dextrin, sucrose, maltose, and inulin, 10-cc. samples were taken from similar test flasks at one-half or one hour intervals, and the relative amounts of cuprous oxide precipitate obtained with Fehling's solution were noted. On this basis the carbohydrates were incubated for the following periods: starch, 45 minutes; dextrin and maltose, 5 hours; sucrose and inulin, 9 hours. The time of incubation for all the other flasks in the experiment,—31 days,—was purely arbitrary, and was based on the extremely slow action of enzymes other than carbohydrases, as observed in previous work in this laboratory.

As in the preliminary experiments already noted, action on carbohydrates was determined in terms of conversion to glucose. In the absence of inversion processes, the Shaffer method adapted for plant analysis, as outlined by Davis ('15), was used. For lipase action 10 cc. from each flask of ester substrate and of oil emulsion were titrated with phenolphthalein against decinormal sodium hydrate. For determining the conversion of amido- and amino-nitrogen into ammonia by the enzymes acting on acetamid and asparagin, the simple and rapid colorimetric method involving the use of "Permutit," recently announced by Folin and Bell ('17), was employed with Kober's modified Dubosc colorimeter. The action of proteolytic enzymes upon their respective substrates was noted in terms of amino-nitrogen split off, using the Van Slyke ('12) "micro" apparatus and 2 cc. of each substrate. Action upon the coagulated albumin in the digestion tubes could of course be estimated only in a general way because of the irregular masses remaining at the close of the experiment.

For the catalase experiments the two lots of *Gladiolus* of 11 corms each, already noted, were employed, after the usual preliminary heating to 30° C., one lot being etherized for 24 hours at that temperature, the other serving as a control. At the close of the etherization period the catalase extract was prepared from both lots of corms by the method outlined by Appleman ('10). In order to eliminate a possible factor of error in catalase determinations caused by differences of time involved in preparation of two lots of extract, both lots of corms were, with the aid of an assistant, treated simultaneously throughout all the processes of enzyme extraction. In a similar manner simultaneous comparison of the action of the two enzyme extracts upon the peroxide solution was made by the use of two sets of apparatus and two observers. After removal from the jars the corms were immediately grated to a fine pulp, with frequent dipping of the grated surface in powdered calcium carbonate to neutralize the action of any acids present, and quickly pressed through a tourniquet of several thicknesses of cheese-cloth. The resulting liquid was

diluted with an equal volume of distilled water previously cooled to low temperature, and both solutions packed in ice until ready for use. The only modifications of Appleman's apparatus were the use of test-tubes of about 100 cc. capacity in place of the bottles used by him for gas generation, and the substitution of a small graduated burette of 25 cc. capacity for the separatory funnel serving as the reservoir of hydrogen peroxide.

In determining oxygen values, 1 or 5 cc. of enzyme extract and 5 cc. of fresh solution of commercial hydrogen peroxide (3 per cent H_2O_2) were allowed to react; readings were made every 30 seconds, allowing 15 seconds for gas generation in the chamber and the same time for displacement of the water in the burettes. Before admitting the peroxide solution the enzyme extract previously placed in the gas chamber was brought to 20° C., and this temperature was maintained throughout the series by keeping the chambers in the constant temperature bath. During periods of gas generation and displacement the test-tubes were constantly shaken by hand in as uniform a manner as possible.

Results and Discussion

In the tables and discussion of results the following system of notation is employed for brevity:

Series A 1.—Enzyme dispersion from tissues extracted immediately after etherization,+ substrate.

Series A 2.—Same dispersion, autoclaved before adding to substrate.

Series B 1.—Enzyme dispersion from controls extracted simultaneously with enzyme of A 1,+ substrate.

Series B 2.—Same dispersion, autoclaved before adding to substrate.

Series C 1.—Enzyme dispersion from tissues extracted 18 hours after etherization,+ substrate.

Series C 2.—Same dispersion, autoclaved before adding to substrate.

Series D 1.—Enzyme dispersion from controls extracted simultaneously with enzyme of C 1,+ substrate.

Series D 2.—Same dispersion, autoclaved before adding to substrate.

In table 1 are given the glucose values obtained by the Shaffer method from the several carbohydrate substrates. The potassium permanganate solution used in the titration was exactly 1/50 normal, 1 cc. being equivalent to 1.272 mg. copper. The amount of sugar per 10 cc. sample of substrate represents the average of two or more titrations,—which did not vary by more than .1–.2 cc. of the permanganate solution,—from which reduction value of the Fehling control has been subtracted.

TABLE I.

THE ACTION OF ENZYMES EXTRACTED FROM ETHERIZED AND UNETHERIZED CORMS OF GLADIOLUS ON CARBOHYDRATES

Substrate		Milligrams sugar as glucose								
		Series number								
		Control	A 1	A 2	B 1	B 2	C 1	C 2	D 1	D 2
Starch	Spl.*	1.2	7.5	1.0	6.6	0.9	2.9	0.7	2.1	0.7
	Tot. sub.†	5.8	36.6	5.2	33.0	4.6	14.6	3.4	10.6	3.4
Dextrin	Spl.	6.0	21.9	5.9	25.6	5.1	13.1	7.9	10.0	14.0
	Tot. sub.	30.0	109.4	29.4	128.2	25.6	65.4	39.4	49.8	70.2
Sucrose	Spl.	22.6 6.4‡	11.4	9.6	8.4	8.9	9.0	10.6	9.7	13.4
	Tot. sub.	113.2 31.8‡	57.0	48.0	42.2	44.4	45.0	52.8	48.6	67.0
Maltose	Spl.	41.2	42.6	42.0	44.3	44.2	42.6	43.6	42.7	42.7
	Tot. sub.	206.2	213.2	210.0	221.6	221.0	212.8	218.0	213.4	213.4
Inulin	Spl.	6.9	6.6	7.4	7.0	6.6	5.8	5.5	5.8	7.8
	Tot. sub.	34.4	33.2	37.0	35.2	32.8	28.8	27.4	28.8	39.2

* Spl.= amount in sample.
† Tot. sub.= total in substrate.
‡ Control minus acid.

The sugar values resulting from the action of the enzyme dispersion on the several carbohydrates are by no means concordant, and in some respects are difficult, if not impossible, to account for adequately. In the case of starch, there appears to be a consistent relation between etherization and an increased hydrolysis. Substrates with enzymes derived from both lots of etherized tissues (A 1 and C 1) are respectively greater than the controls (B 1 and D 1). On *a priori* grounds we should expect no greater starch conversion in the flasks with the previously autoclaved dispersions (A 2, B 2, C 2) than in the control, except such as might be due to hydrolysis by organic acids resulting from the destruction of the dispersion by heat under pressure. We shall see in a consideration of later tables that such increased hydrolysis by the products resulting from disintegration by heat of the enzyme-protein complex appears to be highly probable. In the case of starch, however, the previously autoclaved dispersions seem to have exerted no influence, unless the falling off of the sugar values as compared with the control be regarded as producing an inhibitive or buffer action upon normal processes.

In the case of dextrin the results are not in accord with those just considered, neither are the two halves of the series concordant. The enzyme from the extract made immediately after etherization has been less effective than that from its control; on the other hand, where the corms were allowed to air for 18 hours before extraction, the dispersion from the etherized tissues shows considerable increase in hydrolytic action over its control. The effect of the previously autoclaved dispersions appears to have no great significance here, but attention may be called to the marked increase in the value of D 2 over the other dispersions previously autoclaved. The same relation holds in the series with sucrose and inulin, and seems inexplicable, for if it were due merely to an increased activity resulting from the products of enzyme disintegration, it should have the same relative value with respect to C 2 that B 2 has to A 2,—which is not the case. We are not warranted in explaining the differences in the two halves of this series,—immediate extraction *versus* extraction after air-

ing,—on the hypothesis that such airing has caused an increased conversion of zymogen to enzyme in the case of the etherized corms, because the data for the other carbohydrates show values directly opposed to dextrin in this respect. In view of the relation of dextrin to starch as an intermediate product of the hydrolysis of the latter, the results of the dextrin series are extremely puzzling.

In a consideration of the figures for sucrose it should again be noted that a small amount of acid was added to all substrates in order to make conditions for invertase action more favorable. With this in view, an additional control without acid was used. The latter indicates that in the absence of inhibiting factors, over 71 per cent of the resulting inversion was due to the acid added. That there were inhibiting factors of some nature appears from a study of the remaining figures in the sucrose columns. The relation between the dispersions from etherized and unetherized tissue is apparent, although here also, as in dextrin, there is a contradiction between the two halves of the series. The only plausible explanation lies in the assumption either that no invertase was present in the corms, and that the organic constituents of the protein-enzyme complex merely acted as a buffer on the hydrolytic activity of the hydrochloric acid added to the substrate, or that the invertase present in the corms was either not extracted or was inactivated by the methods employed. The latter assumption appears even less warranted than the first, since the experience of many students of invertase shows that it is one of the enzymes most readily extracted by water.

With respect to the action of the dispersion upon the maltose substrate it appears reasonably clear that there has been no maltase activity, and it is possible that the enzyme was not present. In this case, however, there is experimental evidence that lends support to the belief that the maltase present may have been destroyed in the process of extraction, since Daish ('16) found that the maltase present in air-dried germinated barley was destroyed by extraction with water and subsequent precipitation with alcohol. The figures for inulin show the same general relations of enzyme from ether-

ized tissues and controls that have been noted in the case of dextrin.

The conclusion seems unavoidable, in the light of the results above noted, that for a study of the effect of etherization upon carbohydrates a method must be employed that obviates the various undesirable factors involved in the processes of enzyme extraction. Such extraction and the filtration of dense colloidal plant solutions involve long periods of time which are undoubtedly unfavorable to enzyme isolation. There is the added objection, also apparent in the foregoing table, that there is no means of concluding, in the absence of positive results, whether the enzyme is not present in the tissues or is not amenable to extraction by the method used. Additional data on carbohydrate enzymes with respect to their action following etherization have been obtained in a supplementary series of experiments in which the foregoing difficulties have been eliminated; the results of this series will be discussed later.

The titration of 10-cc. portions of the substrates of ethyl acetate, ethyl butyrate, and oil emulsion, with sodium hydrate showed total absence of lipolytic activity. This was not unexpected, for several reasons. In the first place, experiments showing lipase action have in the past been made for the most part with material of high fat or oil content, such as seeds, especially those of *Ricinus,* rather than with storage organs in which the carbohydrates predominate, such as corms, bulbs, and tubers. Experience has shown that in general, under the most favorable conditions, the amount of active enzyme preparation extracted from plant tissues is quite small in proportion to the amount of material used. The most notable exception in this respect is doubtless the urease derived from several members of the bean family. The chances of obtaining an active lipase preparation from organs such as those used in the present study, even with the most favorable preparation methods, were therefore small.

In the second place, most lipases, as pointed out by Euler ('12), are insoluble in water. Berczeller ('11) concluded that lipase of the pancreas does not go into solution and that the

enzyme acts in a suspension. Oppenheimer ('13) goes further and states that lipases are insoluble in water, glycerin, fats, or ethereal solvents; that the enzyme always acts in suspension. To insure lipolytic action it is therefore desirable either to bring the desiccated plant material containing the enzyme,—preferably after extraction of fats,—directly in contact with the substrate, as suggested by the work of Connstein, Hoyer and Wartenberg ('03) and by Wohlgemuth ('13), or to follow the method cited by Haas and Hill ('17) for extracting the enzyme for commercial usage. In the latter process the seeds or material of high oil content are ground with water, centrifuged, and the resulting emulsion of oil, protein, and enzyme allowed to ferment at a moderate temperature until a scum containing the enzyme rises to the surface. Hydrolysis is effected by allowing this scum to act upon fats in the presence of water and manganese sulphate as a catalyser. In the present study it was not possible to follow either of the methods outlined above for lack of sufficient corms of the kind used in the experiment, and it was necessary to use in the series the enzyme dispersion in aqueous extract to observe a possible, rather than a probable, reaction.

In the following table showing the relations of enzyme extract to acetamid and asparagin the values presented are

TABLE II.

THE ACTION OF ENZYMES EXTRACTED FROM ETHERIZED AND UNETHERIZED CORMS OF GLADIOLUS ON AMIDO AND AMINO COMPOUNDS

Series number	Milligrams ammonia nitrogen from			
	Acetamid		Asparagin	
	In sample	In total substrate	In sample	In total substrate
Control	.0474	2.370	.0396	1.980
A 1	1.7640	88.200	.0388	1.940
A 2	.0476	2.380	.0387	1.935
B 1	.1417	7.085	.0360	1.800
B 2	.0377	1.885	.0248	1.240
C 1	.0423	2.115	.0395	1.975
C 2	.0452	2.260	.0371	1.885
D 1	.0376	1.880	.0313	1.565
D 2	.0406	2.030	.0249	1.245

based upon the colorimetric determinations of 1 cc. of the Nesslerized substrate, measured from an Ostwald precision pipette. The data are the averages of at least two, and in some cases three, such determinations. Two flasks were Nesslerized for each flask of substrate, and four colorimeter readings made from each Nesslerized solution, the ammonia nitrogen being then computed from the average reading. In the case of the acetamid substrate the Nesslerization of the series was repeated to insure a check on the results obtained in the first run.

The results here point to a very definite and a surprisingly great effect of etherization upon the subsequent activity of amidase. The amount of ammonia nitrogen split from acetamid by the enzyme from the etherized tissues is more than twelve times that obtained from the corresponding control. The values for the autoclave dispersions are consistent and correspond closely with that of the control. In the half of the series in which the corms were allowed to air for 18 hours before extraction, there appears no increased action over the control. This tends toward the conclusion that in the time following etherization the period of stimulus resulting from the anaesthetic has been followed by a return to normal conditions, or that during such time the enzyme has completed its activity before extraction.

The data for asparagin, on the other hand, show a practical absence of any enzyme action. The values are in all cases small, and a very accurate distinction between the several Nesslerized solutions was difficult because of the slight amount of color present. It appears clear, however, that there is a marked specificity of action on the part of the enzymes splitting off ammonia.

The analyses of the protein substrates in neutral and alkaline solution for the action of proteolytic enzymes follow. The figures were obtained by translating the volume of nitrogen gas evolved at the observed temperature and pressure into terms of amino-nitrogen in milligrams, using for this purpose the tables of Gattermann ('10) and dividing the values there given by two. Two flasks were unfortunately lost during the

time of incubation by the blowing out of the corks and consequent evaporation.

TABLE III

THE ACTION OF ENZYMES EXTRACTED FROM ETHERIZED AND UNETHERIZED CORMS OF GLADIOLUS ON PROTEINS

Series number	Milligrams amino-nitrogen from albumin			
	Neutral		Alkaline	
	In sample	In total substrate	In sample	In total substrate
Control	.2918	7.294	.2923	7.307
A 1	.4292	10.730	.8291	20.727
A 2	.2951	7.377	.3933	9.837
B 1	.2307	5.767	.4285	10.712
B 2	.2200	5.500	.2486	6.215
C 1	.3970	9.925	†	.....
C 2	.2414	6.035	.2232	5.580
D 1	.2993	7.482	.2551	6.378
D 2	.2762	6.680	.3455	8.637

Series number	Milligrams amino-nitrogen from							
	Casein				Peptone			
	Neutral		Alkaline		Neutral		Alkaline	
	In sample	In total substrate	In sample	In total substrate	In sample	In total substrate	In sample	In total substrate
Control	.6449	16.122	.4642	11.605	.6120	15.300	.6396	15.990
A 1	.9797	24.492	.7427	18.567	.8605	21.512	.8064	20.165
A 2	.7249	18.122	.6790	16.975	.5810	14.525	.5570	13.975
B 1	.8848	22.120	1.4058	35.145	.9381	23.452	.8545	21.362
B 2	.9541	23.852	.4774	11.935	.8117	20.292	.8018	20.045
C 1	.7904	19.760	.6631	16.577	.6737	16.842	.9178	22.945
C 2	1.2060*	30.150*	.4297	10.742	.7056	17.640	1.0022	25.055
D 1	.7427	18.567	†	.....	.7109	17.772	.9534	23.835
D 2	.8929	22.322	.5835	14.587	.6544	16.360	.7016	17.540

* Autoclaved twice after incubation.
† Lost by evaporation in incubator.

The results here vary considerably with the substrate and with the reaction of the solution. In the case of albumin a definite increase in amino-nitrogen may be noted in the flasks acted upon by enzymes from etherized corms, in both halves of the series and in alkaline as well as in neutral media. In the former the action has been practically twice as great as in the neutral albumin. In casein the amino-nitrogen values are as a whole considerably higher than for albumin, but a comparison of the respective controls shows that this may be

largely accounted for by the greater normal hydrolysis of the casein. In neutral solution the dispersion from etherized tissues again shows a greater activity than that from the unetherized corms. In alkaline solution A 1 is markedly less than B 1. Whether this is due to the condition of the medium with respect to the enzyme cannot be determined, unfortunately, since the flask of enzyme control of the second half of this series, D 1, was lost during incubation. It is conceivable that such a great difference might be the result of an error in adding the enzyme dispersion twice to the same flask in preparing the series, although care was taken in this respect. In the peptone substrates, both alkaline and neutral, a retardation or inhibition of the activity of the enzyme from etherized tissues may be noted. This holds for both halves of the series. As a whole, the amount of hydrolysis in the peptone series bears a close relation to that obtained with casein, and is again much greater than that of albumin. In view of the consistent relation of the results with albumin and peptone, in the two halves of a series as well as in acid and alkaline media, we are inclined to ascribe the increased value of B 1 over A 1 in the casein alkaline series to an error of manipulation rather than to any effect upon enzyme action.

In a consideration of the carbohydrate experiments attention was called to the probable effect on hydrolysis of the previously autoclaved dispersions. This appears in several instances in the table above, but the effect is by no means uniform. In three cases (albumin alkaline D 2, and casein neutral B 2 and D 2) it relates to the dispersion from unetherized tissues, and in three others (casein neutral C 2, and peptone neutral C 2 and alkaline C 2), to the controls. No explanation seems sufficient to account for an increase in value obtained from these flasks over those with the corresponding letters, unless such increase is due to the products resulting from the disintegration of the previously autoclaved dispersion. In support of this probability is the value for casein neutral C 2, which, after the second autoclaving, was by mistake subjected to a third autoclaving by another worker in the laboratory. It would appear that the increased number

of subjections to high temperature bears a more or less direct relation to the hydrolysis effected.

The ultimate solution of the coagulated albumin in alkaline media was to be expected, but it had been hoped to obtain comparative data regarding the effect of the enzyme dispersions before complete solution resulted,—and complete solution occurred before the tenth day after incubation began. Observations at intervals of several days, however, showed no detectable difference in the amount of albumin dissolved by the alkaline water of the control and in the flasks containing enzyme dispersion. The results in the case of tubes in acidified water are given below. The average values given in the last column were obtained from the total digestion in three tubes in each flask.

TABLE IV

THE ACTION OF ENZYMES EXTRACTED FROM ETHERIZED AND UNETHERIZED CORMS OF GLADIOLUS ON COAGULATED ALBUMIN IN DIGESTION TUBES IN ACIDIFIED WATER

Series number	Total length in mm. of albumin cylinders digested	Average length in mm. digested from 6 ends of cylinders 2 mm. in diam.
Control	Not measurable	.....
A 1	2.0	0.333
A 2	Not measurable	.....
B 1	12.5	2.083
B 2	Not measurable	.....
C 1	0.5	0.083
C 2	Not measurable	.....
D 1	5.5	0.916
D 2	Not measurable	.....

The relative reactions of the dispersions are here exactly the reverse of those occurring in neutral or alkaline solutions of albumin. While there has been some action on the part of all enzyme mixtures not previously autoclaved, the activity of those from the two lots of unetherized tissues has been notably greater than of those from etherized corms. The results are not readily explained. If the acidity of the medium were in itself the inhibiting factor, an inhibition of both dispersions might be looked for. It would seem, therefore, as if the mixture of enzyme and protein extracted from the etherized tissues differed chemically from that obtained from the control

corms, and that because of such difference the action of the former was retarded in the presence of the acid.

Table v is concerned with the results of the catalase experiments with fresh extracts from the etherized and the control corms.

TABLE V

CATALASE ACTION OF FRESH EXTRACTS OF ETHERIZED AND UNETHERIZED GLADIOLUS CORMS ON HYDROGEN PEROXIDE

Concentration	Time intervals in minutes	Cubic centimeters oxygen from	
		Catalase from etherized corms	Controls
I. 1 cc. extract 1 cc. water 5 cc. H_2O_2	0.5	1.7	2.7
	1.0	1.2	1.3
	1.5	0.8	1.1
	2.0	0.9	0.8
	2.5	1.0	0.8
	3.0	0.5	0.7
Total...	3.0	6.1	7.4
II. 5 cc. extract 5 cc. H_2O_2	0.5	2.0	11.1
	1.0	3.5	12.2
	1.5	3.3	3.3
	2.0	2.5	2.9
	2.5	2.1	2.5
	3.0	1.8	2.1
	3.5	1.7	2.0
	4.0	1.4	1.6
	4.5	1.3	1.5
Total...	4.5	19.6	39.2
III. 5 cc. extract 5 cc. H_2O_2	0.5	16.6	12.0
	1.0	3.2	8.2
	1.5	2.6	4.9
	2.0	2.5	2.8
	2.5	2.1	1.2
	3.0	1.2	1.8
	3.5	1.5	1.6
	4.0	1.0	1.4
	4.5	1.1	1.1
	5.0	1.1	1.1
Total...	5.0	32.9	36.1

The results of the catalase determinations point conclusively to an inhibition of catalytic activity immediately following the period of etherization. This accords in part with the findings of Burge ('17) in his studies of blood catalase. Whether the enzyme returns to normal activity if the corms

are permitted to air for some time after etherization could not be determined with the material at hand, but this is a point worthy of study. In regard to the results obtained, it is of interest to note that they are related to the conclusions of Palladin ('10) and Appleman ('10, '15). The former concluded from experiments with *Vicia Faba* that toxic agents acted as inhibitors of respiration; the latter investigator found that catalase action in the potato bore a direct relation to respiratory activity,—decreasing under the same conditions as respiration.

Experiments with Barley

In view of the inconclusive and inconcordant results obtained from the action of the *Gladiolus* extracts upon the several carbohydrate substrates, it seemed advisable to carry out a supplementary series of experiments with germinated barley, using methods which should exclude the introduction of indeterminable factors of error, or which would at least indicate the source and amount of the error resulting from such methods. An experimental test of the Dubois ('83) theory of the dehydration of tissues by anaesthetics was also made at this time.

The material used was seed of barley (*Hordeum vulgare*). Only plump and apparently viable grains were selected. These were disinfected by the calcium hypochlorite method of Wilson ('15), as modified by Dr. Duggar in this laboratory. The seeds were treated for one hour with a 20 per cent solution of Javelle water, rinsed in tap water, and germinated between moist filter paper. With this treatment germination of more than 95 per cent was secured. A preliminary trial of seeds in 0.1 per cent aqueous solution of mercuric bichloride for two hours proved to be highly injurious, not more than a two or three per cent germination resulting. This is a very much weaker solution than that used by Brown ('09) in his study of seed-coat permeability.

In all cases the seeds were allowed to germinate until the plumules had reached a length of 1–1.5 cm. and the rootlets 1 cm. or less. For the dehydration test two lots of germinated

seeds, 125 in each lot, were used, one being etherized, the other serving as control. The procedure and dosage were the same as in the foregoing experiments, except that the jars containing the material stood at room temperature of about 30° C. Before placing in the jars each lot of seed was wiped between filter paper to remove excess moisture, and weighed. Both jars contained a filter paper sufficiently moist to prevent injury to the seeds by drying out. At the close of the experiment the seeds were again wiped and weighed. The following data were obtained:

TABLE VI

EFFECT OF ETHERIZATION ON THE WEIGHT OF GERMINATING BARLEY

Treatment	No. of seeds	Original weight in gms.	Weight in gms. at end of experiment	Gain in weight		Remarks
				Gms.	Per cent	
Etherized	125	8.43	9.95	1.52	18.0	Plumules 1.5–2 cm. long, etiolated. No growth of radicles.
Control	125	7.90	9.50	1.60	20.2	Plumules 2–3.5 cm. long, partly green. Radicles about same length.

It is evident from the figures above that there was no dehydration as the result of etherization. On the contrary, both lots of seed took up water from the paper in the jars, as indicated by the definite gains in weight. The relative difference in gain, however, is not especially significant, and probably falls within the range of experimental error, considering the fact that in both weighings moist seeds were involved. The most definite results appear in the difference in growth of the two lots of seeds, as indicated in the last column of the table. We have here a corroboration of the findings of other workers in this field, of the inhibitive effect of ether on germinating seeds.

For the experiments with carbohydrate substrates, two lots of selected barley seeds, weighing 150 grams each, were dis-

infected and germinated as already noted. The jars for both lots contained sufficiently moist filter paper to supply the necessary amount of water for the seeds during the usual 24-hour period of etherization, and during this time stood at room temperature of 28–32° C. At the end of the period both the etherized and control seeds were quickly dehydrated by immersion in 50 per cent alcohol for 5 minutes, for 10 minutes in each of two changes of 95 per cent alcohol, and then for 10-minute periods in acetone, 95 per cent alcohol and acetone in the order named. They were then air-dried before an electric fan at high summer temperature. When thoroughly dry both lots were twice ground into coarse meal in a food grinder and finally made into a fine flour by grinding twice in a mill, after which they were stored in desiccators.

The substrates used were a 1 per cent starch solution, made as outlined in the previous work, sucrose (Merck), and maltose (Merck), each in 2 per cent solution. Fifty cc. of each substrate with 1 per cent toluol were used in each flask, and to them were added 5 grams of the respective lots of barley flour. The tests were run at room temperature of 30° C. A preliminary test for amylases was made to determine the length of time desirable to run the series. By the use of the iodine spot-plate test for starch it was found that a little more than 3½ hours elapsed before the action of 5 gms. of either flour acting on 50 cc. of starch solution failed to give positive results. The flasks were therefore allowed to stand for 1¾ hours after adding the flour in the case of the starch, and for 2 hours in the case of sucrose and maltose.

Two flasks of each substrate with flour from etherized barley and a like number with control flour were employed. Fifty cc. of each solution served as a check upon the substrate itself. At the end of the run one flask with etherized and one with control flour were at once heated to 15 pounds pressure in the autoclave, cooled, the mixture centrifuged, and the liquid analyzed for reducing sugars by the Shaffer method. The other pair of flasks was similarly treated, except that the contents were first centrifuged, and the liquid alone then autoclaved. It was believed that a comparison of the values from

the respective flasks would perhaps throw some light upon the effect that autoclaving might exert upon the organic matter present in the flours, as indicated in the sugar determinations.

In the table below the following notation is used:

C.—Substrate with flour from unetherized barley.

Cf.—Substrate with flour from unetherized barley, flour removed before autoclaving.

E.—Substrate with flour from etherized barley.

Ef.—Substrate with flour from etherized barley, flour removed before autoclaving.

Sb.—Substrate control.

TABLE VII

THE ACTION OF FLOUR MADE OF ETHERIZED AND UNETHERIZED GERMINATING SEEDS OF HORDEUM ON CARBOHYDRATES

Substrate		Milligrams sugar as glucose				
		Series letter				
		C	Cf	E	Ef	Sb
Starch	Spl.*	23.53	22.19	22.80	21.49	0.38
	Tot. sub.†	117.65	110.95	114.00	107.45	1.90
Sucrose	Spl.	21.12	21.83	24.76	20.09	8.18
	Tot. sub.	105.60	109.15	123.80	100.45	40.90
Maltose	Spl.	38.63	39.53	37.33	37.82	26.53
	Tot. sub.	193.15	197.65	186.65	189.10	132.65

* Spl.= amount in sample.
† Tot. sub.= total in substrate.

The sugar data above show a consistently lower value for all substrates with flour from etherized seeds, where the substrate was autoclaved after being separated from the solid constituents of the barley. This is also true in most of the substrates where the flour and the solutions were heated together, but there is a marked deviation in the case of sucrose, where E is considerably greater than C. On the other hand, Cf, conforming to the relations holding in the other substrates, is larger than Ef. It is also evident that the relations of C

to Cf and of E to Ef are not the same in the different substrates. In starch, C exceeds Cf, but is less than Cf in sucrose and maltose. E is greater than Ef in starch and sucrose, but falls below Ef in maltose. There seems to be ground for the conclusion that the heating of a substrate containing the enzyme dispersion or the enzyme powder results in the introduction of a disturbing factor that gives inconcordant titration values. On the other hand, the uniform relations between the respective figures for the substrates where the clear liquid was autoclaved lend support to the belief that the removal of the material containing the enzyme before the substrate is heated tends to eliminate or reduce such a factor of error.

Considering the Cf and Ef data alone, therefore, it would appear that in the case of barley the effect of ether upon the germinating seeds is an inhibition of some of their hydrolytic activity, as expressed in terms of action upon an external substrate. This difference in enzyme activity conforms to the differences in growth noted in table v, where control seeds show greater growth than etherized ones. The results support the findings of Lintner and Kröber ('95) and of Eisenberg ('07).

CONCLUSIONS

The experiments here reported may be regarded as a preliminary study of the many questions involved in the problem of anaesthetic action on enzyme activities in plants. The results obtained, although difficult to interpret satisfactorily in the case of some substrates,—notably the carbohydrates in the experiments with *Gladiolus*,—have pointed the way to improved methods of attack. Aside from the substrates just noted, definite results have been obtained with enzyme dispersions acting upon protein and amido substances, and with catalase. The general conclusions appear warranted that tryptic or ereptic enzymes and an amidase were extracted, and that the activity of the dispersions containing these enzymes was in some instances stimulated as the result of etherization; in other cases, as with catalase and with the carbohydrases of germinating barley, the anaesthetic seems to have effected inhibitory action. A very marked increase in action on aceta-

mid following etherization appears concordant with the findings of Willaman ('17) with respect to the effect of ether on enzymes producing cyanogenesis. The experiments do not support the opinion of Johannsen ('97) and do tend to confirm the view of Green ('87) in regard to the conversion of zymogen to enzyme as the result of anaesthetic stimulation. In the case of germinating barley, etherization has resulted either in reduction of the rate of zymogen conversion, or possibly in the production of substances having the properties of anti-enzymes. No conclusions can properly be deduced from a comparison of the results obtained with *Gladiolus* and *Hordeum*. They must be considered separately, for a factor that cannot be neglected is the relation of enzyme response to the rest period of the plant. The assumption is warranted that at certain stages in the life cycle of plants with regular rest periods there will be times of normal maximum and minimum enzyme activity, and the results obtained in etherization experiments will depend upon the application of the narcotic at a time properly related to such normal enzyme conditions. The use of organs with practically indefinite or indeterminate rest periods, such as grain seeds, introduces altogether different conditions. In connection with this phase of the question a study of the effects upon enzyme action resulting from etherization at different periods in the annual cycle of some plant would prove of much value.

Summary

An historical review of the literature of experiments dealing with the responses of plants to anaesthetics is presented, and the several theories of narcosis and of the relation of narcotics to enzyme activity are reviewed.

The methods of experimentation are described.

Among the experimental results obtained, the following are the most definite:

Enzyme dispersions from etherized corms of *Gladiolus* were distinctly more active upon acetamid than dispersions from controls, the ratio of ammonia nitrogen split off from the two series being about 12 to 1. No difference was noted in the

action on asparagin; a specificity of the extracted enzyme is thus indicated.

Dispersions from etherized tissues showed increased proteolytic action on albumin in neutral and in alkaline solutions, and on casein in neutral solutions, as compared with enzymes from controls. With peptone the reverse action was noted, both in neutral and in alkaline media. Action upon coagulated albumin in acid medium was greater in controls than in the dispersions from etherized corms.

Catalase activity appeared to be inhibited as the result of etherization.

Of the experiments with enzyme dispersions from *Gladiolus* on carbohydrates, starch was the only substrate showing consistent results, and these pointed to increased hydrolysis following etherization. Data from the other carbohydrates are conflicting and do not warrant definite conclusions.

The action on carbohydrates of barley flour from etherized and unetherized germinated seeds showed a uniform inhibition resulting from the anaesthetic. It was also shown that anaesthetics do not effect dehydration.

The various data in this study warrant the conclusion that the presence of the colloidal enzyme-protein complex or of solid organic matter, such as meal or flour from tissues, introduces an undesirable source of error if, at the time that enzyme action must be stopped, these substances are heated together with the substrate. The experiments with barley indicate that inhibiting enzyme action after freeing the substrate from insoluble organic matter tends to give more concordant results.

The results as a whole tend to confirm the view that anaesthetics exert a more or less direct influence upon the subsequent activities of plant enzymes.

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THE THELEPHORACEAE OF NORTH AMERICA. X[1]

Hymenochaete

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HYMENOCHAETE

Hymenochaete Léveillé, Ann. Sci. Nat. Bot. III. **5**: 150. 1846; Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 333. 1868; Cooke, Grevillea **8**: 145. 1880; Sacc. Syll. Fung. **6**: 588. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 95. 1890; Engl. & Prantl, Nat. Pflanzenfam. (**1**: 1**): 121. 1898.

Fructifications coriaceous to hard, of varied form from stipitate to resupinate; hymenium even or rarely granular, containing slender, somewhat conical, colored setae between the basidia; basidia simple; spores hyaline, even.

There is no type species, for this genus is a fine example of basing the generic conception upon a group of thelephoraceous species, some stipitate, some dimidiate, some reflexed, and some resupinate, which agree in having setae in the hymenium.

In addition to the distinctive morphological character of elongated, conical setae in the hymenium, there is also a chemical substance in the tissue of all the species of *Hymenochaete* which I have studied, that causes an immediate darkening of sections when dilute potassium hydrate is brought in contact with them. This darkening is so great as to make the sections too opaque for study if more than a mere trace of this usually useful reagent is employed to swell the sections. One has to use instead lactic acid to have the sections remain clear enough to show their fine structural details. The greatly elongated, colored cystidia and conducting organs which are present in the deeper tissue and curve into, or even protrude above, the hymenial surface in some species of *Stereum*, as, for example, *S. umbrinum*, *S. abietinum*, *S. glaucescens*, etc.,

[1] Issued December 23, 1918.

have been confused by some authors with setae and have led to the publication of several such species under *Hymenochaete*. Istvanffi[1] has shown that there is a fundamental difference between such organs and the conical, pointed setae which are characteristic of *Hymenochaete*. In any doubtful case which the student may meet it would be well to aid conclusion by the color reaction with solution of potassium hydrate already mentioned. In my experience the dimensions of setae are not sufficiently constant to hardly more than grade these organs as large, medium, and small.

According to our present knowledge, *Hymenochaete* attains its greatest development both in form and in number of species in the western continent where it culminates in a small group of indigenous stipitate species. Temperature conditions are important in the geographical distribution of the species of this genus; this is shown by the long east and west range across North America of common species, in comparison with the much shorter north and south range. Furthermore, *Hymenochaete* is a genus of tropical species rather than of the cooler portion of the north temperate zone, for in contrast with the 29 species occurring from the Gulf States to Brazil only 13 species are known north of the latitude of Virginia, and from Europe perhaps 9 species, of which 6 are well known.

Original descriptions of the species of *Hymenochaete* have required considerable modification with regard to characters referring to form, because they were based upon too limited an amount of material. In the case of species of *Thelephoraceae* growing on prostrate logs, the inclination of the substratum at the point of attachment and the position of the substratum as to whether over or under the fructification are important in determining the habit and form of the fructification. For example, a species present in quantity on a log slightly raised above the ground will often show fine resupinate specimens on the under side of the log; about an eighth of a circumference up the side of the log the upper margin is reflexed, becoming longer reflexed and with a shorter resu-

[1] Physiologische Anatomie der Pilze. Jahrb. f. wiss. Bot. **29** : 410. 1896.

pinate base as the fungus occurs higher on the side of the log; beyond one-fourth of a circumference upward from the bottom of the log, umbonate-sessile, dimidiate, and flabelliform specimens are frequently collected. I have a fine campanulate specimen of *Stereum fasciatum* which I found on the top of a log surrounded by this species. For these reasons the form of fungi growing on prostrate logs is not as reliable a character as it is in case of species growing on the ground or in the case of a flowering plant, and a student having in hand only a resupinate or only a flabelliform fructification from some herbarium must not be too confident that the respective species are always resupinate or always flabelliform.

The degree of differentiation in structure of the fructification of *Hymenochaete* has not been used in systematic work heretofore, so far as I am aware. Such structure affords, however, constant, positive, fundamental characters of easy determination. In the simplest condition of the fructification in this genus, only a setigerous layer is present, in the next degree higher of development, a hyphal layer connects the setigerous layer with the substratum or may be extended from the substratum as the upper surface of the pileus; in a still more highly developed condition, the hyphal layer is differentiated into an intermediate layer and a denser and dark zone, and usually into a second hyphal layer adnate to the substratum or forming the surface of the pileus.

Key to the Species

Fructifications in preparations of sections show at least both a setigerous layer and a hyphal layer destitute of setae 1
Fructifications lack a hyphal layer, i. e., have the setigerous layer seated directly on the substratum 16
Fructifications dimidiate or flabellate, of unknown structure ....*37. H. pallida*
1. Not stratose, i. e., consisting of but one setigerous layer of more or less thickness and of a hyphal layer 2
1. Stratose, composed of two or more strata, of which each consists of a setigerous layer and a hyphal layer 6
2. Hyphal layer simple and homogeneous throughout, i. e., not with a portion differentiated as an internal or bordering, conspicuously denser and darker zone 3
2. Hyphal layer not simple but differentiated into an intermediate layer and at least a bordering, denser and darker zone on the side towards the substratum or upper surface of the reflexed part 9
3. Fructification stipitate, erect; stem with two or more short branches at or near its apex and each bearing an expanded pileus ..*1. H. damaecornis*

3. Old, dark, zonate specimens of above.....*Stage *H. formosa*
3. Fructification stipitate, erect; stem bearing a single reniform pileus.... .....*2. H. reniformis*
3. Not stipitate, but resupinate, or with pileus reflexed or sessile..... 4
4. Always resupinate so far as known yet. Guard against locating here the first-stratum stage of the stratose species and resupinate stages of reflexed species of the *H. aspera* group..... 5
4. Reflexed or dimidiate; resupinate specimens of *H. Cacao* and *H. aspera* have been found and perhaps may yet be found for the other species in this group..... 7
5. Fructification clay-color to antique brown, 100–140 μ thick, with hyphae loosely interwoven, suberect, 3–4 μ in diameter; setae 30–75×6–8 μ, scattered in the outer half of fructification; on *Corylus, Ostrya*, and *Vaccinium* .....*18. H. arida*
5. Hyphal layer very thin usually and may be overlooked unless substratum is included in the sections; setigerous layer up to 500 μ or more thick, zonate; causes a pocketed rot of wood; in Cuba, Venezuela, and Brazil .....*19. H. unicolor*
5. Hyphal layer 1–2 mm. thick, very compact; setae few, 70–90×9 μ, starting from the dark subhymenium; parasitic on living limbs of *Alnus, Benzoin*, etc., where they rub together.....*20. H. agglutinans*
6. Not cracked, antique brown to Brussels-brown, finally 2–6 strata thick, with the setigerous layers 30–45 μ thick and equalled or exceeded by the alternating hyphal layers.....*21. H. cinnamomea*
6. Not cracked, antique brown to Brussels-brown, finally up to 15 strata thick; strata with layers thinner than in the preceding species; paraphyses colored, with branched tips; in Panama .....*22. H. digitata*
6. Cracking in drying, Argus-brown, very compact, finally several strata thick, with setigerous layers 45–200 μ thick, and exceeding the hyphal layers.....*23. H. spreta*
7. Setigerous layer 90 μ thick, with setae crowded together in all its parts; in Cuba, Jamaica, and Venezuela.....*3. H. Cacao*
7. Setigerous layer not more than 60 μ thick..... 8
8. Pileus rough on the upper side with strigose, matted fibers; hymenium granular like that of *Thelephora terrestris;* margin with bright-colored mycelial strands; in Cuba, Jamaica, and Venezuela .....*4. H. aspera*
8. Pileus bay, sericeous, becoming somewhat zonate, radially plicate; margin lobed, often proliferous, yellow ocher; setae very large, 90–120×12–15 μ; in Jamaica and Guiana.....*5. H. Berkeleyana*
8. Pileus Argus-brown above and beneath, concentrically sulcate and somewhat zonate and shining above, very thin and papery; setae 65–90×9–10½ μ; in South Carolina and the West Indies to Chile .....*6. H. Sallei*
8. Pileus Brussels-brown to cinnamon-brown, radiately fibrillose with adnate fibrils, concentrically ridged; hymenium snuff-brown; setae 60–90×7½–10 μ; from Ontario to New Jersey....*7. H. borealis*
9. Setigerous layer not more than 50 μ thick..... 10
9. Setigerous layer more than 50 μ thick..... 13
10. Always resupinate so far as known. Compare also *H. Curtisii* and *H. rigidula*, which are sometimes resupinate..... 11
10. Usually reflexed or dimidiate, sometimes resupinate..... 12
11. Hymenium Isabella-color to tawny olive, cracked, margin somewhat sulphur-yellow; the adnate, bordering, dark zone next to substratum absent in some places; from Alabama to Mexico.....*24. H. epichlora*
11. Hymenium between wood-brown and Saccardo's umber; intermediate layer, connecting dark zone, and hyphal layer adnate to substratum are present; in Cuba.....*25. H. dura*
12. Becoming narrowly reflexed, Benzo-brown, rather rigid; hymenium Benzo-brown; setae crowded together in all parts of the setigerous layer; in Cuba and Venezuela.....*8. H. rigidula*

12. Resupinate or reflexed, drying pliant, antique brown; hymenium velvety, antique brown; setae few and usually far apart, 60–70×6–8 μ; Massachusetts to Texas and westward to Oregon .....*9. H. Curtisii*

12. Dimidiate and imbricated, or effuso-reflexed, concentrically sulcate, Argus-brown, pliant; hymenium buckthorn-brown; setae few and far apart, 30×5–6 μ; Porto Rico to Venezuela and Guiana..... .....*10. H. luteo-badia*

13. Always resupinate so far as known yet. Compare *H. tabacina* and *H. rubiginosa* which are frequently resupinate..... 14

13. Usually reflexed or dimidiate, sometimes resupinate..... 15

14. 200–700 μ thick, tawny olive to Brussels-brown, separable from the substratum; a narrow, dark zone divides the hyphal layer into an intermediate layer and a broad layer attached to the substratum; Arkansas to Mexico and in Cuba.....*26. H. leonina*

14. 120–260 μ thick, fulvous; lower dark zone is adnate to substratum; cystidia present; in Louisiana and Jamaica.....*27. H. fulva*

14. 120–240 μ thick, between Verona-brown and cinnamon-drab, slightly glaucous, adnate; lower dark zone bordering the intermediate layer is adnate to substratum; paraphyses colored, with pinnatifid tips; Georgia to Mexico, and in Cuba and Jamaica..*28. H. pinnatifida*

15. Usually reflexed, sometimes resupinate, thin, sericeous, and antique brown at first, finally glabrous and deep brownish drab, the margin and intermediate layer orange-yellow; hymenium snuff-brown to sepia, deeply cracked in resupinate portions into radiating systems, about one system for each centimeter of area; common throughout Canada and United States.....*11. H. tabacina*

15. Fructifications imbricated, conchiform, umbonate-sessile, or reflexed, sericeous, lineate-radiate, becoming variegated with concentric brown zones; closely related to *H. tabacina* but not cracking into radiating systems; found on vertical surfaces; Canada to Carolina..... .....*12. H. badio-ferruginea*

15. Reflexed, sometimes resupinate, coriaceous-rigid, thick, concentrically sulcate, Brussels-brown, becoming fuscous-black, the margin ochraceous-tawny; hymenium colliculose, bister, with conspicuous setae; Canada to Mexico and westward to the Pacific, and in Porto Rico.*13. H. rubiginosa*

15. Broadly reflexed, coriaceous-rigid, shallowly concentrically sulcate, zonate, Prout's brown; hymenium even, Sudan-brown; setigerous layer zonate, 300–400 μ thick, having scattered setae 35–40×4½–5 μ; in Jamaica.....*14. H. reflexa*

15. Imbricated, flabelliform, dimidiate, umbonate-sessile, or reflexed, thin, pliant when dry, concentrically sulcate, becoming snuff-brown to Rood's brown; hymenium even, antique brown; setigerous layer 80–100 μ thick, having setae 35–45×4½–6 μ; in Cuba and Porto Rico.....*15. H. cubensis*

16. Fructifications somewhat hoof-shaped, sessile, with a black, hard crust on the upper side; hymenium whitish, 3 mm. thick, zonate within; in Mexico.....*16. H. ungulata*

16. Fructification with upper edge sometimes barely reflexed, and black; hymenium drab, 400–1000 μ thick; growing on bark of living trunks of oak, elm, etc.; New Jersey to Florida and in the West Indies.....*17. H. corticolor*

16. Always resupinate so far as known..... 17

17. Setae crowded, 27–45×4½–5 μ; hymenium cinnamon-brown to Prout's brown; in Cuba and Jamaica.....*29. H. multisetae*

17. Colorless, incrusted cystidia and colored setae present, the setae about 30×4½ μ, only rarely emergent; hymenium vinaceous-buff; in Cuba.. .....*30. H. anomala*

17. Having setae larger than 27–45×4½–5 μ and not having cystidia..... 18

18. Cinnamon-brown to bister and Rood's brown, cracked into small 4–6-sided areas, 150–500 μ thick; setae 60–70×8–12 μ, starting in all parts of the fructification; Canada to Texas, westward to Kentucky, and in Jamaica.....*31. H. corrugata*

18. Tawny olive, not cracked, up to 90 μ thick; setae 60–90×9–12 μ, all starting from the dark zone next to the substratum; Vermont to Pennsylvania and Illinois.....*32. H. episphaeria*
18. Dresden-brown, differs in structure from *H. episphaeria* by having spores 7–9×3½ μ and by containing crystalline masses 12–15 μ in diameter; in Louisiana and Cuba.....*33. H. cervina*
18. Between bister and Vandyke-brown, slightly velvety when young, becoming glabrous, cracked, 200–300 μ thick, dark and opaque; setae 50–90×8–10 μ, starting in all parts of the fructification; in Jamaica .....*34. H. opaca*
18. Raw umber to mummy-brown, somewhat cracked, 30–75 μ thick; setae 36–45×5–7 μ; on *Thuja* and *Tsuga;* Vermont to Florida and in British Columbia.....*35. H. tenuis*
18. Bister to warm sepia, somewhat colliculose, not cracked; 150–200 μ thick; setae abundant, 60–75×8–9 μ, starting in all parts of the fructification; with general aspect of resupinate *H. rubiginosa* but thin and adnate; in Vermont, Maryland, Ohio, and Kentucky .....*36. H. fuliginosa*

Arrangement of the Species

I. Stipitate species 1– 2
II. Dimidiate, umbonate-sessile and reflexed species, many of which occur resupinate.
a. Hyphal layer not differentiated into an intermediate layer proper and a bordering, denser, dark zone on its upper side..... 3– 7
b. Hyphal layer differentiated into an intermediate layer and at least a bordering, denser, dark zone on its upper side.
* Setigerous layer not more than 50 μ thick..... 8–10
** Setigerous layer more than 50 μ thick..... 11–15
c. No hyphal layer..... 16–17
III. Resupinate species, none of which occur reflexed.
a. Hyphal layer not differentiated into an intermediate layer proper and a bordering, denser, dark zone on the side towards the substratum.
* Not stratose 18–20
** Stratose 21–23
b. Hyphal layer differentiated into an intermediate layer and at least a bordering, denser, dark zone on the side towards the substratum.
* Setigerous layer not more than 50 μ thick..... 24–25
** Setigerous layer more than 50 μ thick..... 26–28
c. No hyphal layer—setigerous layer seated directly on the substratum. No. 17 is nearly always resupinate.
* Setae small, 27–45×4½–5 μ..... 29
** Both setae and colorless, incrusted cystidia present..... 30
*** Setae larger than 27–45×4½–5 μ and not having cystidia.. 31–36
IV. Dimidiate, somewhat flabellate species whose structure is not known... 37

1. Hymenochaete damaecornis Link ex Léveillé, Ann. Sci. Nat. Bot. III. **5** : 151. 1846; Sacc. Syll. Fung. **6** : 589. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 96. 1890. Plate 16, fig. 1.

Stereum damicorne Link, Ges. Naturforsch. Freunde Berlin Mag. **3** : 40. 1809; Fries, Epicr. 546. 1838; R. Soc. Sci. Upsal. Actis III. **1** : 109. 1851; Lloyd, Letter 46 : 6. 1913.—*Thelephora damaecornis* Link ex Fries, Linnaea **5** : 524. 1830.—*Hymeno-*

chaete formosa Léveillé, Ann. Sci. Nat. Bot. III. **5** : 151. 1846. —An *Thelephora speciosa* Fries, Linnaea **5** : 525. 1830?

Fructifications with several to many pilei borne on very short branches of a common central stem at or near its apex; stem cylindric, velutinous with setae, hazel to Brussels-brown; pilei coriaceous, thin, expanded, drying strongly inrolled, even or sometimes rugose, silky and antique brown when young, finally glabrous except for setae which are scattered over the upper surface and more abundant towards the stem, bister, and sometimes concentrically zonate with narrow dark zones near the margin; hymenium a little darker than the upper surface, Prout's brown to Mars brown, abundantly and conspicuously setulose; in structure 200–500 μ thick, composed of a setigerous layer up to 150 μ thick and of a hyphal layer constituting the remainder and not bordered on either side by a dense, dark zone; setae 90–150×9–15 μ, emerging up to 60 μ, tapering upward from the base, starting from all parts of the setigerous layer; spores hyaline, even, 5–5½× 4–4½ μ.

Fructifications 3–15 cm. high, 1½–3 cm. broad; individual pilei 1–1½ cm. long, 1–3 cm. broad; stem 2–14 cm. long, 2–3 mm. in diameter in dried specimens not cited under *H. formosa* on a following page.

On roots of trees and among leaves in thick woods. West Indies and Mexico to Brazil. October to March.

H. damaecornis exhibits wide variation in the dimensions of its fructifications and in the number of pilei which are borne on the central stem; the short branches of the latter are somewhat flattened in radial planes with respect to the central stem if so many pilei are present that some are borne along the sides of the stem below the terminal cluster. Where only four pilei are present in a symmetrical terminal cluster, there is bifurcation of the main stem into two flattened branches, and of these again into the more broadly flattened bases of the individual pilei. There is often a curious twisting of the end of the branch and base of the pileus through an angle of 90 degrees to bring the plane of the pileus dorsiventral, if we may compare it with a leaf. In this connection,

the lateral pilei of *H. Schomburgkii* in Hennings' figure in Engler & Prantl's 'Nat. Pflanzenfam.' are perhaps conventional. In the collection made in Jamaica by Murrill and Harris, 1057, as cited below, there is one old fructification with pileus dark-colored and obscurely zonate which could be referred to *H. formosa;* this fructification is in a cluster of younger, azonate fructifications. The specimen upon which Fries based his *Thelephora speciosa* was evidently a fructification of *H. damaecornis* with upper surface of the pilei bearing more setae than the normal, for he gives its distinctive character as "undique velutino" and on the preceding page has described the stem of *H. damaecornis* as "velutinus," which we know to be by setae. The specimen collected by Peck in Providence, New York, which is cited in Sacc. 'Syll. Fung.' as the northern station of *Hymenochaete speciosa,* has no setae and should not have been referred to this species. I have omitted reference to Plumier, Filic. Am. pl. 168. figs. H, K, as illustrations of *H. damaecornis,* for it is incredible that the draftsman who executed pls. 1–167 of that work could have had before him a specimen of *H. damaecornis* when he made figs. H and K of pl. 168.

Specimens examined, additional to those cited under *H. formosa:*

Cuba: *C. Wright, 272* (Curtis Herb.); Sierra Nipe, Oriente, *J. A. Shafer, 3326* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55553).

Jamaica: Mabiss River, *L. M. Underwood, 1399,* comm. by N. Y. Bot. Gard. Herb.; Troy and Tyre, *W. A. Murrill & W. Harris, 1057* (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 55552, and in Burt Herb.).

Honduras: *M. E. Peck* (in N. Y. Bot. Gard. Herb.).

* Stage **H. formosa** Léveillé, Ann. Sci. Nat. Bot. III. **5** : 151. 1846; Sacc. Syll. Fung. **6** : 589. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 96. 1890.—Compare Bresadola, Hedwigia **35** : 289. 1896. Plate 16, fig. 2.

An *Hymenochaete Schomburgkii* Hennings in Sacc. Syll. Fung. **9** : 227. 1891; Engl. & Prantl, Nat. Pflanzenfam. (**I.** 1**) : 121. *f. 68 F.* 1898?

Illustrations: Broteria **5**: *pl. 2. f. 3.*

Fructifications with several to many pilei borne on very short branches of a common central stem at or near its apex; stem cylindric, velutinous with setae, hazel to Brussels-brown; pilei coriaceous, thin, expanded, drying strongly inrolled, even or sometimes rugose, silky and antique brown when young, finally glabrous except for setae which are scattered over the upper surface and more abundant towards the stem, bister, concentrically zonate, with narrow, dark zones near the margin; hymenium a little darker than the upper surface, Prout's brown to Mars brown, abundantly and conspicuously setulose; in structure 250–400 μ thick, composed of a setigerous layer up to 150 μ thick and of a hyphal layer constituting the remainder, and not bordered on either side by a denser dark zone; setae 90–150×9–15 μ, emerging up to 40 μ, tapering upward from the base, starting from all parts of the setigerous layer; spores not found.

Fructifications 5–8 cm. high, 2–3 cm. broad; individual pilei up to 2 cm. broad and 2 cm. long in specimens seen; stem 3–5 cm. long, 2–4 mm. in diameter in dried specimens.

On the ground and buried wood. Guadaloupe and Honduras to Brazil. October.

I have seen only two collections which seem referable to *H. formosa* and the one of these from Honduras contains a young, bright-colored fructification which affords the details concerning the young stage given in the body of the above description and does away with the distinction as to zonation of pileus upon which Léveillé founded *H. formosa,* the original description of which appears to have been based upon an old form of *H. damaecornis* at a period in mycological work when mere form differences were over-emphasized. I give *H. formosa* with full description in the hope that more ample collections may be accumulated which are not confined to a single stage of development.

Specimens examined:

Exsiccati: Rick, Fungi Austro-Am., 10.

British Honduras: *M. E. Peck* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55551).

Brazil: Sao Leopoldo, Rio Grande do Sul, *J. Rick*, in Rick, Fungi Austro-Am., 10.

2. **H. reniformis** (Fries) Léveillé, Ann. Sci. Nat. Bot. III. **5**: 151. 1846; Cooke, Grevillea **8**: 145. 1880; Sacc. Syll. Fung. **6**: 588. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 96. *pl. 5. f. 1.* 1890; Romell, K. Svenska Vet.-Akad. Bihang till Handl. Afd. III. **26**[16]: 42. 1901.

Stereum reniforme Fries, Epicr. 546. 1838; R. Soc. Sci. Upsal. Actis III. **1**: 109. 1851; Léveillé, Ann. Sci. Nat. Bot. III. **2**: 210. 1844; Berkeley, Ann. & Mag. Nat. Hist. **10**: 382. *pl. 11. f. 11.* 1842.

"*S. reniforme,* coriaceum, cinnamomeum, pileo dimidiato *reniformi* integerrimo *zonato,* stipite e basi torulosa decumbente adscendente, hymenio laevi velutino. In American calidiori. Eumorphum, subvelutinum. Pileus uncialis."

—Original description of Fries.

In typical specimens of this species a single reniform pileus is borne at the apex of the stem. Berkeley, *loc. cit.,* referred to this species a specimen whose pileus is slightly bilobed, which he figured, and he noted that the whole fructification was sprinkled with short, bright, brown setae. Romell describes the spores as hyaline, obliquely ellipsoidal, 5–6×4 μ.

H. reniformis has been collected several times in Brazil but not yet in the West Indies or Central America, so far as I know.

3. **H. Cacao** Berkeley, Linn. Soc. Bot. Jour. **10**: 333. 1868; Linn. Soc. Trans. II. **1**: 403. *pl. 46. f. 1–3.* 1879; Sacc. Syll. Fung. **6**: 592. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 100. 1890.

Stereum Cacao Berkeley, Hooker's London Jour. Bot. **6**: 169. 1854.

Illustrations: Linn. Soc. Trans. II. **1**: *pl. 46. f. 1–3;* Engl. & Prantl, Nat. Pflanzenfam. (I. 1**) : 122. *text f. 68 D, E.*

Type: in Kew Herb. and a portion in Mo. Bot. Gard. Herb.

Fructifications sessile, flabelliform, connate, deeply lobed and plicate, upper surface velvety, concentrically sulcate, Brussels-brown; hymenium between fuscous and blackish

brown (3); in structure 600 μ thick, composed of a setigerous layer 90 μ broad and of a hyphal layer 500 μ broad, having densely arranged, colored hyphae 4½ μ in diameter, running longitudinally, curving on the one side into the hymenium and on the other into the surface of the pileus; setae ventricose at base, 18×4½–5 μ, densely crowded together in all parts of the broad setigerous layer; spores hyaline, even, 4×3 μ.

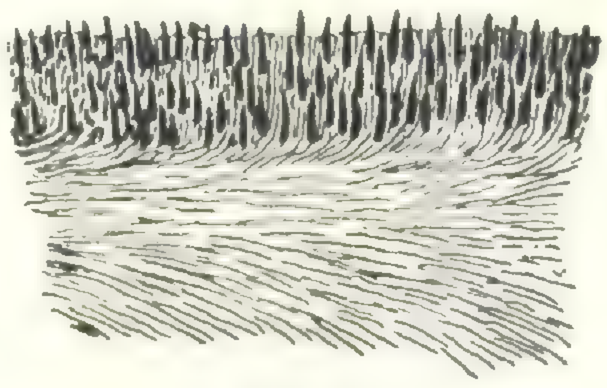


Fig. 1
H. Cacao.
Section × 68. From type.

Fructifications 3½ cm. broad, 3 cm. long.

On dead wood. Jamaica, Cuba, and Venezuela. July. Rare.

By the kindness of Sir David Prain, I have been able to study a portion of the type of *H. Cacao* collected in the Khasia Mountains, India; it has the hymenium olive-drab now but is of the same form and structure as American specimens. The American specimens are a rich tobacco-brown with darker hymenium. This species is noteworthy by having the setae densely crowded together through a zone 90 μ broad. The collection by Earle, 406, cited below, seems referable to *H. Cacao* on account of the color of the hymenium and structure in section but it is wholly resupinate.

Specimens examined:

India: Khasia Mts., *Dr. Hooker,* portion of type comm. by Sir David Prain (in Mo. Bot. Gard. Herb., 55559).

Jamaica: Cinchona, *F. S. Earle, 406,* comm. by N. Y. Bot. Gard. Herb., and *W. J. Robinson* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55481).

Cuba: *C. Wright, 526* (in Curtis Herb.).

Venezuela: *Fendler* (in Curtis Herb.).

4. H. aspera Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 334. 1868; Sacc. Syll. Fung. **6**: 592. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 100. 1890.

An *Hydnum resupinatum* Swartz, Prodr. 149. 1788; Fl. Ind. Occ. **3**: 1921. 1806?—An *Thelephora setosa* Swartz in Berkeley, Ann. & Mag. Nat. Hist. **10**: 381. *pl. 11. f. 10.* 1842? Not *Hymenochaete setosa* Berk. & Curtis, Grevillea **1**: 165.

1873; Sacc. Syll. Fung. **6**: 538. 1888.—*Hydnochaete setosa* (Swartz) Lloyd, Myc. Notes 41: 559. *text f. 766.* 1916.

Illustrations: Berkeley, Ann. & Mag. Nat. Hist. **10**: *pl. 11. f. 10;* Lloyd, Myc. Notes 41: 559. *text f. 766.*

Type: in Kew Herb. and Curtis Herb., and of *Thelephora setosa* in Brit. Mus. Herb.

Fructifications broadly reflexed and with a narrow, resupinate base, or dimidiate, sessile, imbricated, laterally confluent, very thin, drying pliable, with upper surface rough with coarse, strigose, matted fibers, very shallowly concentrically sulcate; hymenium granular, snuff-brown; in structure 150–400 μ thick, with a narrow setigerous layer consisting of the hymenium, and with the hyphal layer composed of longitudinally arranged, colored hyphae 2 μ in diameter which curve outward and become interwoven to form the upper surface of the pileus—no dense, dark zones present; setae scattered, 60–75×6 μ, tapering from the base, emerging up to 30 μ, some starting from the subhymenium but mostly from the hymenium; spores hyaline, even, 3×2 μ as seen on basidia.

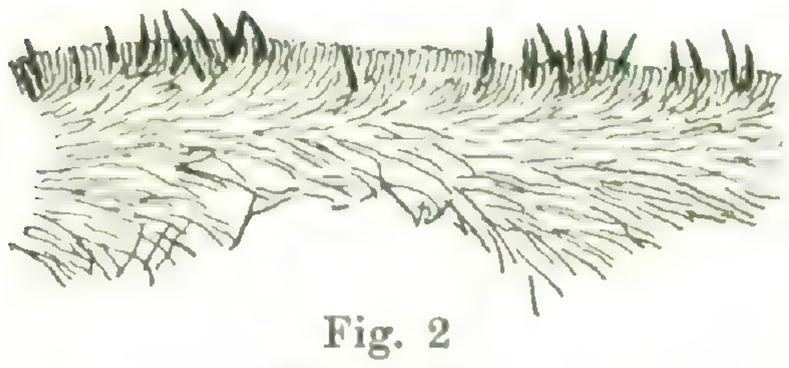


Fig. 2
H. aspera.
Section × 68. See *pl. 16, f. 3.*

Pilei of fructifications 1–2½ cm. long, 1–5 cm. broad, sometimes resupinate on areas up to 5×3 cm.

On dead frondose wood on the ground in forests. Cuba, Jamaica, and Venezuela. October to March.

H. aspera may be recognized by its thin, pliant pileus, which is rough on the upper surface with strigose matted fibers, by granular hymenium which is as granular as in *Thelephora terrestris,* and by the short, brighter-colored mycelial strands which form the resupinate margin.

Specimens examined:

Cuba: *C. Wright, 211,* type (in Curtis Herb.); Alto Cedro, *F. S. Earle, 340, Earle & Murrill, 488,* and *Underwood & Earle, 1513,* all from N. Y. Bot. Gard. Herb.; Ciego de Avila, Puerto Principe, *Earle & Murrill, 605,* comm. by N. Y. Bot. Gard. Herb.

5. H. Berkeleyana (Montagne) Cooke, Grevillea **8**: 147. 1880; Sacc. Syll. Fung. **6**: 596. 1888.

Stereum Berkeleyanum Montagne, Ann. Sci. Nat. Bot. IV. **1**: 140. 1854; Syll. Crypt. 178. 1856.

Type: authentic specimen in Kew Herb.—probably portion of type.

Fructifications effuso-reflexed, cespitose-imbricated, often dimidiate, radiately rugose, sericeous, with the hairs radially decumbent, bay, becoming somewhat zonate with interrupted blackish zones, radially plicate, the margin lobed, sometimes proliferous, yellow ocher; hymenium not rimose, antique brown; in structure 500–600 μ thick, with the hyphal layer not bordered on either side by a dark, dense zone, and composed of closely and longitudinally arranged, colored, very thick-walled hyphae $3\frac{1}{2}$–4 μ in diameter and up to 5 μ on the upper surface of the pileus; setae scattered, not crowded, 90–120×12–15 μ, emerging 60–75 μ, tapering from the base upward to a slender point; spores hyaline, even, $6\times3\frac{1}{2}$ μ.

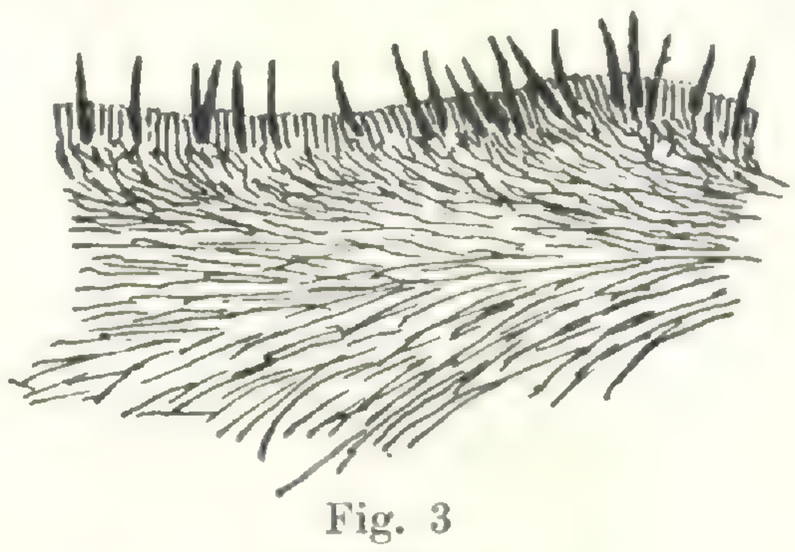


Fig. 3
H. Berkeleyana.
Section × 44. See *pl. 16, f. 5.*

Fructifications with reflexed part 1 cm. broad, 1 cm. long, laterally confluent into clusters up to 3 cm. broad.

On bark and rotten wood. Jamaica and Guiana. December and January. Rare.

The general aspect of *H. Berkeleyana* is suggestive of that of *H. badio-ferruginea* but the former has its pilei more crowded together than the latter and radially plicate. The absence of any dark zones bordering the intermediate layer of *H. Berkeleyana* sharply separates this species from the *H. tabacina* group when sections are examined, and places the species in the group with *H. attenuata* and *H. Sallei,* from both of which it is distinct by its plicate, more crowded pilei, covering of the pilei, and larger setae. I had not received the collections from Jamaica, cited below, when I studied the authentic specimen from Montagne at Kew, but these later

collections agree so well with the original description and my preparation of *H. Berkeleyana* that I regard them as certainly the same species.

Specimens examined:

Jamaica: Chester Vale, *W. A. & Edna L. Murrill, 371,* comm. by N. Y. Bot. Gard. Herb.; Cinchona, *W. A. & Edna L. Murrill, 445,* comm. by N. Y. Bot. Gard. Herb.

Guiana: Cayenne, from Montagne (in Kew Herb.).

6. H. Sallei Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 333. 1868; Cooke, Grevillea **8**: 146. 1880; Sacc. Syll. Fung. **6**: 593. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 101. 1890.

Stereum elegantissimum Speggazini, Soc. Cientif. Argentina Anal. **16**: 38. 1883.—*Hymenochaete elegantissima* (Speg.) Sacc. Syll. Fung. **6**: 594. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 99. 1890.—*Stereum tenuissimum* Fries, R. Soc. Sci. Upsal. Actis III. **1**: 111. 1851, but not of Berkeley, Hooker's London Jour. Bot. **6**: 510. 1847.—*Hymenochaete tenuissima* Berkeley, Linn. Soc. Bot. Jour. **10**: 333. 1868, but not *Stereum tenuissimum* Berkeley, Hooker's London Jour. Bot. **6**: 510. 1847.

Illustrations: Broteria **5**: *pl. 2. f. 4.* 1906.

Type: in Kew Herb. and Curtis Herb.

Fructifications very thin, papery, flexible when dry, umbonate-sessile and laterally confluent, or reflexed and imbricated,

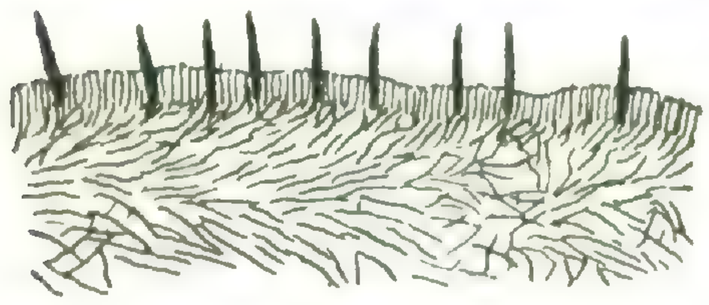


Fig. 4
H. Sallei.
Section × 68. From type.
See *pl. 17, f. 15.*

at first fibrous on the upper surface, antique brown, soon silky-fibrous, with the fibers radially arranged, Argus-brown to auburn, concentrically sulcate, and at length somewhat zonate and shining, the margin lobed; hymenium Argus-brown; in structure 200–400 μ thick, with the hyphal layer simple, not bordered by a dark zone, composed of somewhat loosely interwoven and longitudinally arranged, thick-walled, colored hyphae 3½–4½ μ in diameter; setae 65–90×9–10½ μ, emerging up to 60 μ, starting from the subhymenium which is not ap-

preciably darker than adjacent tissue; spores hyaline, even, 3–4×1½–2½ μ.

Fructifications 1½–3 cm. in diameter and laterally confluent, or with reflexed part 1–2½ cm. long, up to 4 cm.., and more, broad by lateral confluence.

On dead twigs, prostrate limbs, and at base of trees of frondose species. South Carolina, West Indies, Mexico, and South America to Paraguay and Chile. September to May. Common.

Fully developed specimens of *H. Sallei* may be recognized by their thin, papery pileus which may be folded without breaking, which is a rich Argus-brown both on the upper side and hymenium, and concentrically sulcate, somewhat zonate, and shining on the upper side also. Collections of young specimens of this species when first found were referred by early authors to *H. tenuissima,* a Ceylon species, of which good material is now available for comparison in the collection from Ceylon distributed in Sydow, Fungi Exotici Exs., 318, and in Elmer, Philippine Island Plants, 9850, both of which I have compared with a portion of the type communicated by Sir David Prain through the kindness of Miss Wakefield. The true *H. tenuissima* has its upper surface clothed with coarse pubescence, as stated in the original description, and the fibers of this pubescence do not finally become decumbent, radiately arranged, and the surface shining; the hymenium of *H. tenuissima* is somewhat radiately rugose and between Isabella-color and Dresden-brown — not antique brown.

Specimens examined:

Exsiccati: Balansa, Pl. du Paraguay, 3916, under the name *Hymenochaete elegantissima;* Ravenel, Fungi Am., 718, under the name *Hymenochaete badio-ferruginea;* Rick, Fungi Austro-Am., 31, under the name *Hymenochaete tenuissima;* Smith, Central Am. Fungi, 149, under the name *Hymenochaete tabacina.*

South Carolina: Seaboard, *H. W. Ravenel,* in Ravenel, Fungi Am., 718.

Florida: *C. G. Lloyd, 2071.*

Cuba: *C. Wright, 278,* type (in Kew Herb. and in Curtis Herb.), and *531,* under the name *H. tenuissima* (in Kew Herb.), and *275,* under the name *H. tenuissima* (in Curtis Herb.); Alto Cedro, *F. S. Earle, 339,* and *Earle & Murrill, 514, Underwood & Earle, 1512, 1569, 5182,* all comm. by N. Y. Bot. Gard. Herb.; Artemisa, *O. Ames & R. G. Leavitt,* comm. by W. G. Farlow; El Yunque, Mt. Baracoa, *Underwood & Earle, 765, 1235,* comm. by N. Y. Bot. Gard. Herb.; La Gloria, Camagüey, *J. A. Shafer, 741* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55509); Omaja, *C. J. Humphrey, 2750* (in Mo. Bot. Gard. Herb., 8639); Sierra Nipe, *J. A. Shafer, 3375* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55510); Tacajo, Nipe Bay, *F. S. Earle, B.*

Porto Rico: Espinosa, *J. A. Stevenson, 6373* (in Mo. Bot. Gard. Herb., 55081).

Jamaica: Castleton Gardens, *F. S. Earle, 246,* comm. by N. Y. Bot. Gard. Herb.; Cinchona, *W. A. & Edna L. Murrill, 445,* comm. by N. Y. Bot. Gard. Herb.; Mandeville, *A. E. Wight,* comm. by W. G. Farlow; Mansfield, near Bath, *Wm. R. Maxon,* comm. by W. G. Farlow, and *L. M. Underwood, 2780,* comm. by N. Y. Bot. Gard. Herb.; Moore Town, *W. A. & Edna L. Murrill, 162, 1113,* comm. by N. Y. Bot. Gard. Herb.; Troy and Tyre, *L. M. Underwood, 2970,* comm. by N. Y. Bot. Gard. Herb., and *W. A. Murrill & W. Harris, 858, 924, 1010,* comm. by N. Y. Bot. Gard. Herb.

St. Kitts: Molyneaux Estate, *N. L. Britton & J. F. Cowell, 338,* comm. by N. Y. Bot. Gard. Herb.

Grenada: Grand Etang, *R. Thaxter,* comm. by W. G. Farlow, 1.

Mexico: Cordoba, *Salle* (in Kew Herb.); Xuchiles, Cordoba, *W. A. & Edna L. Murrill, 1215* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54606); Jalapa, *W. A. & Edna L. Murrill, 190* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54447), and *C. L. Smith,* in Smith, Central Am. Fungi, 149; Orizaba, *W. A. & Edna L. Murrill, 751, 794* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54630, 54642).

Brazil: Rio Grande do Sul, *J. Rick,* in Rick, Fungi Austro-Am., 31.
Paraguay: in Balansa, Pl. du Paraguay, 3916 (in Kew Herb.).
Chile: Central Chile, *R. P. Nataniel Costes* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 44782).

7. **H. borealis** Burt, n. sp.

Type: in Burt Herb.

Fructifications thin, pliant, imbricated, reflexed, attenuated towards the base, or umbonate-sessile and attached along one side, radiately fibrillose, concentrically ridged, Brussels-brown to cinnamon-brown; hymenium even, not cracked, snuff-brown; in structure 240–340 μ thick, with the setigerous layer 60 μ thick, and with the hyphal layer not bordered on either side by a dense, dark zone, and having its hyphae rather loosely interwoven and longitudinally arranged, colored, $2\frac{1}{2}$ μ in diameter; setae scattered, 60–90$\times 7\frac{1}{2}$–10 μ, emerging up to 60 μ, starting from all parts of the setigerous layer; spores hyaline, even, 4–6$\times$2–3 μ.

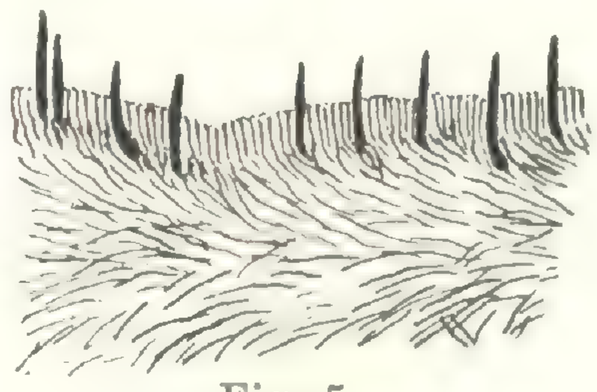


Fig. 5
H. borealis.
Section × 68. From type.
See *pl. 16, f. 6.*

Fructifications 8–12 mm. in diameter, reflexed portion up to 4 mm. long.

On decorticated frondose wood. Ontario to New Jersey. October to April. Rare.

H. borealis is distinguished by having a simpler structure in section than any other of the pileate species which occur in the north. The absence of dark, dense zones bordering on an intermediate layer separates it at once from *H. badio-ferruginea. H. attenuata* of the East Indies is a closely related species but the latter has its pileus strigose-hirsute.

Specimens examined:

Ontario: London, *J. Dearness, 1017* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55513).
Vermont: Abby Pond, Ripton, *E. A. Burt,* type.
New Jersey: Newfield, *J. B. Ellis* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55503).

8. H. rigidula Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 334. 1868; Cooke, Grevillea **8**: 146. 1880; Sacc. Syll. Fung. **6**: 593. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 99. 1890.

An *H. fulvella* Berk. & Curtis in Cooke, Grevillea **8**: 148. 1880; Sacc. Syll. Fung. **6**: 598. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 104. 1890?—An *H. pulcherrima* Massee, Linn. Soc. Bot. Jour. **27**: 104. *pl. 5. f. 4.* 1890; Sacc. Syll. Fung. **9**: 229. 1891?—An *H. scruposa* Massee in Cooke, Grevillea **20**: 11. 1891; Sacc. Syll. Fung. **11**: 123. 1895?

Type: in Kew Herb. and Curtis Herb.

Fructifications resupinate, effused, becoming narrowly reflexed, lobed, coriaceous, rather rigid, with the upper surface of the reflexed part velvety, snuff-brown at first, later Benzo-brown; hymenium Benzo-brown, ochraceous-tawny near the margin; in structure 300–500 μ thick, with the setigerous layer 30–45 μ broad and with the intermediate layer comprising most of the thickness of the fructification and bordered on each side by a narrow, dense, dark zone, of which that on the setigerous side is the less distinct; hyphae of intermediate layer 3–4 μ in diameter, colored, somewhat interwoven and longitudinally arranged; setae conical, 30–45×6–8 μ, larger ones sometimes found, emerging up to 30 μ, very numerous, starting from all portions of the setigerous layer; spores probably hyaline, even, 4×1½–2 μ.

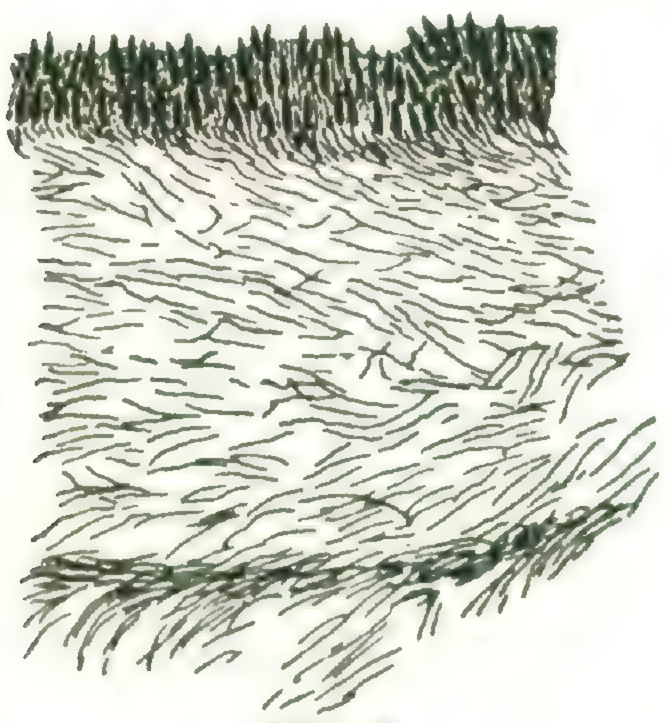


Fig. 6
H. rigidula.
Section × 68. From type.

Fructifications with reflexed portion ½–1 cm. long, resupinate over areas 4×1–1½ cm.

On dead wood and bark of frondose species. Cuba and Venezuela. March. Rare.

On account of the dark zones bordering its intermediate layer, *H. rigidula* belongs in the small group, of which *H. tabacina* and *H. rubiginosa* are more common examples; it is distinguishable from all these species by the great number and crowded arrangement of its setae in the setigerous layer,

a feature which it shares with *H. Cacao*. *H. rigidula* differs from *H. Cacao* by having its intermediate layer bordered by a prominent dark zone on its outer side, by being effuso-reflexed, and with less black in the color of its hymenium. In dried condition it is more rigid than *H. tabacina* and the other species of its group with the exception of *H. rubiginosa*, from all forms of which it may be distinguished at sight by less conspicuous setae when viewed with a hand lens and by the much thinner, setigerous layer when sections are examined. So few spores of *H. rigidula* have been seen in the preparations that the spore dimensions given are very doubtful. My belief in the specific identity of *H. fulvella* is based upon the similarity of sectional preparations; since noting this similarity of structure, I have not had an opportunity to confirm my opinion by placing the original specimens side by side and comparing them with regard to general aspect. I did not find *H. pulcherrima* when I was at Kew, and in reply to my letter to Miss Wakefield concerning the original Fendler number for this type, Sir David Prain has written, "With regard to *H. pulcherrima* Mass., the specimen indicated by Massee as No. 3721a was removed by him from a gathering of *H. fulvella* B., the label of which, in Berkeley's handwriting, is 'Stereum fulvellum B. & C. 173, Venezuela.' Massee named it on the sheet 'H. scruposa,' but evidently he changed the name before publishing it."—It seems probable that in the year following the publication of *H. pulcherrima*, Cooke saw the specimen upon which it was based, still labelled with only the herbarium name *H. scruposa* Massee and published the latter. I have studied the specimen in Curtis Herbarium labelled "*Stereum fulvellum* B. & C., Fendler, 173. Venezuela" and found it to have the characteristic structure of *H. rigidula* and *H. fulvella* and to agree well with the published descriptions of *H. fulvella*, *H. pulcherrima*, and *H. scruposa*.

Specimens examined:

Cuba: *C. Wright, 529*, type (in Kew Herb. and in Curtis Herb.); Herradura, *Earle & Murrill, 170*, comm. by N. Y. Bot. Gard. Herb.; San Diego de los Baños, *Earle & Murrill, 219*, comm. by N. Y. Bot. Gard. Herb.

Grenada: Grand Etang, *R. Thaxter*, comm. by W. G. Farlow.
Venezuela: *Fendler, 175*, type of *Hymenochaete fulvella* (in Kew Herb.), and *173* (in Curtis Herb., under the name *Stereum fulvellum*).

9. **H. Curtisii** (Berk.) Morgan, Cincinnati Soc. Nat. Hist. Jour. **10**: 197. 1888.

Stereum Curtisii Berkeley, Grevillea **1**: 164. 1873; Sacc. Syll. Fung. **6**: 581. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 195. 1890.

Type: type distribution in Ravenel, Fungi Car. **3**: 26.

Fructifications at first orbicular, then effused, confluent, becoming reflexed, coriaceous, thin, separable, drying pliant, the upper surface at first silky, fibrillose, somewhat concentrically ridged, antique brown, becoming glabrous and hair-brown when old; hymenium not cracking, velvety, antique brown; in structure 140–240 μ thick, with intermediate layer bordered by a narrow, dense, dark zone towards the upper surface of the pileus or the substratum, the hyphae densely and longitudinally arranged, colored, thin-walled, $2\frac{1}{2}$ μ in diameter; setae few and far apart usually, 60–70×6–8 μ, emerging up to 45 μ, tapering upward to a sharp point; spores hyaline, allantoid, 6–7×$1\frac{1}{2}$–2 μ.

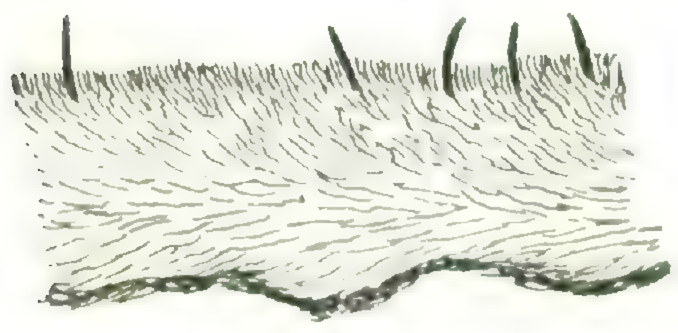


Fig. 7
H. Curtisii.
Section × 68. From type.
See *pl. 17, f. 9.*

Fructifications confluent along under side of limbs for 2–20 cm. or more, $1\frac{1}{2}$–$2\frac{1}{2}$ cm. broad; reflexed lobes 5 mm. long, 10–15 mm. broad.

On rotting limbs of *Quercus* and other frondose species. Massachusetts to Texas and westward to Oregon—in low altitudes. April to December. Common.

H. Curtisii may be recognized by its rich antique brown color, thin, pliant, reflexed portions, velvety hymenium which is not at all cracked, and by the notable scarcity of setae which cannot be found in the hymenium with a pocket lens and are sometimes lacking in thin sections in microscopic prepara-

tions. The geographical range of *H. Curtisii* overlaps on the north the southern range of *H. tabacina,* and it is itself displaced in the West Indies, Mexico, and further south by *H. Sallei.*

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 2381, 2882, 4290, 4635; Ellis, N. Am. Fungi, 16; Ell. & Ev., Fungi Col., 103; Rabenhorst-Winter, Fungi Eur., 3525, under the name *Stereum tabacinum,* with note; Ravenel, Fungi Am., 222, 446; Fungi Car. **3**: 26; de Thümen, Myc. Univ., 113.

Massachusetts: Cambridge, *L. M. Underwood, 1080* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55542); East Sudbury, *A. B. Seymour, T 18* (in Seymour Herb., and in Mo. Bot. Gard. Herb., 18349).

Connecticut: Central Valley, *J. L. Sheldon, 5,* comm. by N. Y. Bot. Gard. Herb.

New York: Grand View, *H. von Schrenk* (in Mo. Bot. Gard. Herb., 43024); New York Botanical Garden, Bronx Park, *Class in Mycology* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55533); Staten Island, *S. C. Edwards,* in Lloyd Herb., 06902; White Plains, *W. H. Ballou* (in Mo. Bot. Gard. Herb., 55032).

New Jersey: from Laning Herb. (in Mo. Bot. Gard. Herb., 5182); Forked River, *W. H. Ballou, 2;* Lakefield, *E. A. Daniels,* comm. by H. Webster; Newfield, *J. B. Ellis,* comm. by Lloyd Herb., also (in Mo. Bot. Gard. Herb., 55534), and in Ellis, N. Am. Fungi, 16, in Ell. & Ev., Fungi Col., 103, and in de Thümen, Myc. Univ., 113.

Pennsylvania: from Michener Herb., two specimens (in Mo. Bot. Gard. Herb., 55528, 55529); Bethlehem, *Schweinitz* (in Herb. Schweinitz, under the name *Thelephora leprosa* of Syn. N. Am. Fungi, No. 636); Ohio Pyle, *W. A. Murrill, 1067* (in N. Y. Bot. Gard. Herb.).

Maryland: Hyattsville, *F. L. Scribner, 83,* comm. by U. S. Dept. Agr. Herb.; Takoma Park, *C. L. Shear, 1074.*

District of Columbia: *W. A. Murrill, 1464* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55535); Takoma Park, *P. L. Ricker, 819.*

Virginia: *W. A. Murrill* (in N. Y. Bot. Gard. Herb.); Arlington, *W. H. Long, 12690* (in Mo. Bot. Gard. Herb., 44164); Mt. Vernon, *P. L. Ricker, 1122;* Woodstock, *C. L. Shear, 1190.*

North Carolina: *H. W. Ravenel* (in Curtis Herb., 1646).

South Carolina: *H. W. Ravenel,* type distribution, in Ravenel, Fungi Car. **3**: 26; Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 446; Clemson College, *P. H. Rolfs, 1822, 1823,* and *H. D. House,* in Bartholomew, Fungi Col., 2381.

Georgia: Darien, *H. W. Ravenel,* in Ravenel, Fungi Am., 222.

Florida: *C. G. Lloyd, 2116* (in Lloyd Herb.); West Palm Beach, *R. Thaxter, 83* (in Mo. Bot. Gard. Herb., 43900).

Alabama: Auburn, *F. S. Earle, 123,* and *an unnumbered specimen* (in Mo. Bot. Gard. Herb., 55537, 55538); New Albany, *A. B. Seymour, 2930* (in N. Y. Bot. Gard. Herb.).

Mississippi: Jackson, *E. Bartholomew, 5791* (in Mo. Bot. Gard. Herb., 44123), and in Bartholomew, Fungi Col., 4635; Ocean Springs, *F. S. Earle, 182* (in Mo. Bot. Gard. Herb., 5176), and *an unnumbered specimen,* comm. by U. S. Dept. Agr. Herb.

Louisiana: Acadia Parish, *A. B. Langlois;* Alden Bridge, *W. Trelease* (in Mo. Bot. Gard. Herb., 5169); St. Martinville, *A. B. Langlois,* comm. by Lloyd Herb., 2423.

Texas: Gonzales, *C. L. Shear, 1230;* Houston, *H. W. Ravenel, 36, 38, 134, 160,* comm. by U. S. Dept. Agr. Herb.

Ohio: Oberlin, *F. D. Kelsey, 821* (in N. Y. Bot. Gard. Herb.).

Kentucky: Crittenden, *C. G. Lloyd, 3126;* Mammoth Cave, *C. G. Lloyd, 1189.*

Tennessee: Elkmont, *C. H. Kauffman, 76* (in Mo. Bot. Gard. Herb., 44997).

Wisconsin: Blue Mounds, *Miss A. O. Stucki, 29,* Univ. of Wisconsin Herb.; Madison, *W. Trelease, 77, 79* (in Mo. Bot. Gard. Herb., 5169, 5170, and in Seymour Herb.), and *Miss A. O. Stucki, 63,* Univ. of Wisconsin Herb.

Minnesota: Princeton, *C. J. Humphrey, 990* (in Mo. Bot. Gard. Herb., 10274).

Missouri: Bismarck, *L. O. Overholts* (in Mo. Bot. Gard. Herb., 55539); Columbia, *B. M. Duggar, 88;* Perryville, *C.*

H. Demetrio, in Rabenhorst-Winter, Fungi Eur., 3525; Jefferson Barracks, St. Louis, *E. A. Burt,* and *L. O. Overholts* (in Mo. Bot. Gard. Herb., 43774 and 44049 respectively).

Arkansas: Batesville, *E. Bartholomew,* in Bartholomew, Fungi Col., 2882; Cass, *W. H. Long, 19804* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 9141).

Oklahoma: Spiro, *E. Bartholomew,* in Bartholomew, Fungi Col., 4290.

Nebraska: Long Pine, *V. B. Walker, 9* (in Mo. Bot. Gard. Herb., 13932).

Oregon: Portland, *J. R. Weir, 544* (in Lloyd Herb., 0311, and in Mo. Bot. Gard. Herb., 19624).

10. H. luteo-badia (Fries) v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116** : 754. 1907.

Thelephora luteo-badia Fries, Linnaea **5** : 526. 1830.—*Stereum luteo-badium* Fries, Epicr. 547. 1838; Sacc. Syll. Fung. **6** : 571. 1888; Lloyd, Letter 46 : 6. 1913.—*Thelephora Kunzei* Hooker, Bot. Misc. **2** : 163. *pl. 85.* 1831.—*Hymenochaete Kunzei* (Hooker) Massee, Linn. Soc. Bot. Jour. **27** : 100. 1890; Sacc. Syll. Fung. **11** : 122. 1895.—*Stereum laetum* Berkeley, Acad. Nat. Sci. Phila. Jour. **2** : 279. 1853.—*Hymenochaete laeta* Berkeley in Cooke, Grevillea **8** : 146. 1880; Sacc. Syll. Fung. **6** : 591. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 99. 1890.—*Stereum pulchrum* (Schweinitz) Cooke in Sacc. Syll. Fung. **6** : 561. 1888.

Illustrations: Hooker, Bot. Misc. **2** : *pl. 85.*

Type: type distribution in Weigelt Exs., under the name *Thelephora badia* Hook.?—a specimen in Mo. Bot. Gard. Herb., 5205.

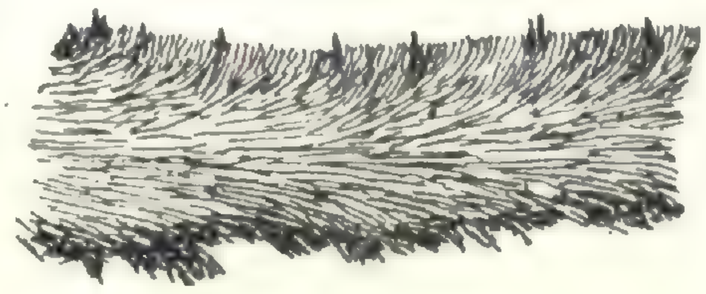


Fig. 8
H. luteo-badia.
Section × 68. From type.
See *pl. 17, f. 11.*

Fructifications dimidiate and imbricated or effuso-reflexed, lobed, very thin, coriaceous, pliant when dry, velvety when young, becoming somewhat glabrous and minutely fibrillose when older, concentrically sulcate, and sometimes zonate or radiately rugose, drying Argus-brown; hymenium even, dry-

ing buckthorn-brown; in structure 200–300 μ thick, with a broad, compact intermediate layer of longitudinally arranged, colored hyphae 2–2½ μ in diameter, which is connected with the velvety covering of the upper surface of the pileus by a narrow, dark zone; setae very few, tapering from the base, 30×5–6 μ, emerging 10–20 μ above the hymenium; spores hyaline, even, 4–4½×2½ μ.

Fructifications 1½–2½ cm. long, 2–4 cm. broad; resupinate portion of reflexed specimens may be up to 3 x 2 cm. in specimens seen so far.

On rotting trunks of frondose species. Porto Rico to Venezuela and Guiana. May. Probably common.

H. luteo-badia is a beautiful tropical species which is well characterized by its name, for the contrast in color between the buckthorn-brown or tawny olive hymenium and the Argus-brown (chestnut color) upper surface of the pileus is a constant and distinguishing character; setae are as few and far apart in the hymenium as they are in *H. Curtisii;* the absence of a dark subhymenial zone bordering the hyphal layer is an additional character which separates *H. luteo-badia* from many other species of *Hymenochaete.*

Specimens examined:

Porto Rico: Ponce, *F. S. Earle, 114, 159,* comm. by N. Y. Bot. Gard. Herb.

Trinidad: Sangre Grande, *R. Thaxter,* comm. by W. G. Farlow, 29.

Venezuela: *Fendler 174* (in Curtis Herb.); Margarita, *A. F. Blakeslee,* two collections, comm. by W. G. Farlow.

British Guiana: *Sir R. Schomburgh,* comm. by G. Bresadola; also specimen under name *Thelephora laeta,* ex. Hooker Herb. (in Herb. Berkeley in Kew Herb.).

Dutch Guiana: Surinam, *Weigelt,* distributed under the name *Thelephora badia* Hook.?, the type distribution of both *Thelephora luteo-badia* and *Thelephora Kunzei* (in Mo. Bot. Gard. Herb., 5250); specimen from Herb. Schweinitz under the herbarium name *Thelephora pulchra,* type of both *Stereum laetum* and *Stereum pulchrum* (in Curtis Herb.).

11. H. tabacina Sowerby ex Léveillé, Ann. Sci. Nat. Bot. III. **5** : 152. 1846; Cooke, Grevillea **8** : 145. 1880; Sacc. Syll. Fung. **6** : 590. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 112. 1890.

Helvella nicotiana Bolton, Hist. Funguses, 174. *pl. 174*. 1789.—*Auricularia tabacina* Sowerby, British Fungi, *pl. 25*. 1797.—*Thelephora tabacina* (Sow.) Fries, Syst. Myc. **1** : 437. 1821; Elenchus Fung. **1** : 173. 1828.—*Stereum tabacinum* (Sow.) Fries, Epicr. 550. 1838; Hym. Eur. 641. 1874.—*Thelephora avellana* Fries, Syst. Myc. **1** : 442. 1821 (in part); Elenchus Fung. **1** : 188. 1828 (in part).—*Stereum avellanum* Fries, Epicr. 551. 1838 (in part); Hym. Eur. 642. 1874 (in part).—*Hymenochaete avellana* (Fr.) Cooke, Grevillea **8** : 146. 1880; Sacc. Syll. Fung. **6** : 592. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 103. 1890.—*Thelephora imbricatula* Schweinitz, Am. Phil. Soc. Trans. N. S. **4** : 166. 1832.—*Hymenochaete imbricatula* (Schw.) Léveillé, Ann. Sci. Nat. Bot. III. **5** : 152. 1846; Cooke, Grevillea **8** : 146. 1880; Massee, Linn. Soc. Bot. Jour. **27** : 103. 1890.—*H. imbricata* Sacc. Syll. Fung. **6** : 593. 1888.

Illustrations: Bolton, Hist. Funguses, *pl. 174;* Sowerby, British Fungi, *pl. 25*—type illustration.

Fructifications coriaceous, effuso-reflexed, often imbricated, sometimes wholly resupinate, thin, sericeous, antique brown, at length becoming glabrous and deep brownish drab, the margin and intermediate layer orange-yellow; hymenium snuff-brown to sepia, often deeply cracked where resupinate, with a series of radial anastomosing cracks for each centimeter of area; in structure 340–600 μ thick, with the setigerous layer 100 μ thick, and with the intermediate layer bordered on each side by a narrow, dark, dense zone; hyphae $2\frac{1}{2}$–3 μ in diameter, orange-yellow, longitudinally arranged in the intermediate layer; setae 60–90×6–12 μ, emerging up

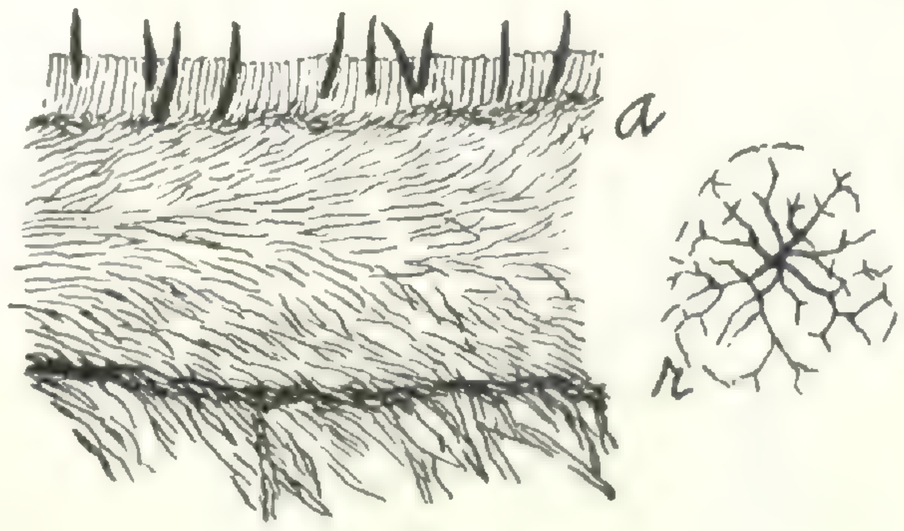


Fig. 9
H. tabacina.
Section, *a*, × 68; system of radiating cracks in hymenium, *r*, × 4½. See *pl. 17, f. 16.*

to 50 μ, originating from all parts of the setigerous layer although chiefly from the dark, subhymenial zone; spores hyaline, even, curved, 5–6$\times$1½–2 μ, as seen in preparation of sections.

Reflexed portion 3–7 mm. long, 10–15 mm. broad, often laterally confluent; resupinate portions up to 3$\times$30 cm. and more.

On dead limbs, usually of frondose species. Canada to Mexico, Maine to the Pacific coast, Alaska to California. Common in the north, rare further south. Throughout the year.

H. tabacina is the commonest species of its genus in the northern United States and may be recognized by its reflexed fructifications tobacco-colored with bright golden yellow margin and intermediate layer, and by having the hymenium deeply cracked in resupinate portions into radiating systems, one system for about each centimeter of area. The specimen under the name *Stereum avellanum* from Fries in Kew Herb. is the old glabrous, somewhat reddish stage of *H. tabacina;* this specimen has led to the transfer of *Stereum avellanum* to *Hymenochaete* by British authors and Saccardo. An older specimen of *Thelephora avellana* in Herb. Fries collected by E. Fries at Femsjö is not distinct from *Stereum glaucescens* but is unfortunately on coniferous wood, while *T. avellana* was published as occurring on *Corylus,* a frequent substratum in Europe for *H. tabacina.* The type of *Thelephora imbricatula* in Herb. Schweinitz is a mixture of *Hymenochaete tabacina,* mounted on the right of the card, and of *H. corrugata,* mounted at the left. Both these species are present in the sample of *T. imbricatula* in Curtis Herb. but their order has been reversed in mounting. The portion of the original description pertaining to characters of reflexed portions of the fructifications is obviously based upon the *H. tabacina* portion of the type. Since Léveillé's transfer of *T. imbricatula* to *Hymenochaete* was probably based upon an authentic specimen from Schweinitz in Museum of Paris Herb., in 1846, this specimen will probably show whether any of *H. corrugata*

was mixed in the type of *H. imbricatula* as distributed by Schweinitz.

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 3134; Berkeley, Brit. Fungi, 248; Ellis, N. Am. Fungi, 13; Ell. & Ev., Fungi Col., 102; Krieger, Fungi Sax., 270; Libert, Pl. Crypt. Arduennae, 121; Oudemans, Fungi Neerlandici Exs., 240; Shear, N. Y. Fungi, 314; de Thümen, Myc. Univ., 211, 211b.

Finland: Mustiala, *P. A. Karsten,* in de Thümen, Myc. Univ., 211.

Sweden: *L. Romell, 37, 38;* Stockholm, *L. Romell, 342.*

Germany: Saxony, in Krieger, Fungi Sax., 270.

Austria-Hungary: Trient Alps, *J. Bresadola.*

Holland: in Oudemans, Fungi Neerlandici Exs., 240.

England: in Berkeley, Brit. Fungi, 248.

France: *F. Fautrey* (in Lloyd Herb., 3316).

Belgium: in Libert, Pl. Crypt. Arduennae, 121.

Newfoundland: *A. C. Waghorne* (in Mo. Bot. Gard. Herb., 5179, 5180); Chappel, *A. C. Waghorne, 12* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 5178).

Quebec: Gaspé, *J. Macoun, 244;* Montreal, *R. J. Blair,* comm. by L. O. Overholts, 3814 (in Mo. Bot. Gard. Herb., 54993).

Ontario: Bond Lake, *J. H. Faull,* Univ. of Toronto Herb., 351 (in Mo. Bot. Gard. Herb., 44881); London, *J. Dearness;* Ottawa, *J. Macoun, 22, 229;* Port Credit, *J. H. Faull,* Univ. of Toronto Herb., 350, 351 (in Mo. Bot. Gard. Herb., 44876, 44866); Toronto, *Thos. Langton,* Univ. of Toronto Herb., 502 (in Mo. Bot. Gard. Herb., 44843); Wilcox Lake, *G. H. Graham,* Univ. of Toronto Herb., 686 (in Mo. Bot. Gard. Herb., 44940).

Maine: Orono, *P. L. Ricker* (in Seymour Herb.); Piscataquis County, *W. A. Murrill, 1943, 2007, 2075, 2110, 2175* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55522–6); Penobscot County, *W. A. Murrill, 1802* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55527); Pittston Farm, *E. R. Hodson,* comm. by P. L. Ricker, 202; Portage, *L. W. Riddle, 5.*

New Hampshire: Chocorua, *W. G. Farlow,* two collections; Gilmanton, *J. Blake,* comm. by P. L. Ricker; Mt. Wonalancet, *H. von Schrenk* (in Mo. Bot. Gard. Herb., 42846); North Woodstock, comm. by Univ. of Wisconsin Herb., 11; Shelburne, *W. G. Farlow* (in Mo. Bot. Gard. Herb., 4782), and *H. von Schrenk* (in Mo. Bot. Gard. Herb., 5172).

Vermont: Abby Pond, Ripton, *E. A. Burt;* Little Notch, *E. A. Burt;* Lost Pleiad Pond, *E. A. Burt;* North Ferrisburg, *E. A. Burt;* Ripton, *E. A. Burt.*

Massachusetts: Cambridge, *G. R. Lyman;* Fresh Pond, *G. R. Lyman;* Magnolia, *W. G. Farlow;* Sharon, *A. P. D. Piguet,* comm. by W. G. Farlow, 1 (in Mo. Bot. Gard. Herb., 55006).

Connecticut: Central Village, *J. L. Sheldon,* comm. by N. Y. Bot. Gard. Herb.; Norwich, *W. A. Setchell.*

New York: *Torrey,* part of type of *Thelephora imbricatula* Schw. (on right of card in Herb. Schweinitz and on left of card in Curtis Herb.); Adirondacks, *G. F. Atkinson, b;* Alcove, *C. L. Shear, 1101, 1308,* and in Shear, N. Y. Fungi, 314; Altamont, *E. A. Burt;* Brookton, *H. Fitzpatrick, 1054* (in Mo. Bot. Gard. Herb., 54773); East Galway, *E. A. Burt,* two collections; Fort Ann, *S. H. Burnham, 18* (in Mo. Bot. Gard. Herb., 54422); Freeville, *G. F. Atkinson, 2584;* Riverside Park, New York City, *H. J. Whittemore, 18* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55511); Vaughns, *S. H. Burnham, 10* (in Mo. Bot. Gard. Herb., 44001).

New Jersey: Forked River, *W. H. Ballou, 3;* Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 13, in Ell. & Ev., Fungi Col., 102, and in de Thümen, Myc. Univ., 211b.

Pennsylvania: State College, *A. S. Rhoads & C. R. Orton, 12* (in Mo. Bot. Gard. Herb., 44092); Trexlertown, *W. Herbst,* comm. by Lloyd Herb., 3593; Wright's Gap, *A. S. Rhoads,* comm. by L. O. Overholts, 3409 (in Mo. Bot. Gard. Herb., 7152).

Delaware: Wilmington, *A. Commons, 1427* (in N. Y. Bot. Gard. Herb.).

North Carolina: Blowing Rock, *G. F. Atkinson, 4031, 4331.*

Michigan: Ann Arbor, *L. N. Johnson, 1654* (in N. Y. Bot. Gard. Herb.); Glen Lake, *C. G. Lloyd, 02554, 02555;* Isle Royal, *Allen & Stuntz, 41, 43,* both comm. by Univ. of Wisconsin Herb.; Vermillion, *A. H. W. Povah, 141, 138, 311, 193, 147, 358, 351, 188, 213, 149, 192, 197, 70, 328* (in Mo. Bot. Gard. Herb., 15588, 17200, 16526, 20697, 21065, 21552, 22080, 20470, 20615, 20650, 20674, 22122, 22322, and 22350 respectively).

Wisconsin: Madison, *V. B. Walker, 8* (in Mo. Bot. Gard. Herb., 11963).

Minnesota: Lake Itaska, comm. by E. L. Jensen, 7 (in Mo. Bot. Gard. Herb., 10372).

Missouri: Cox's Switch, *H. von Schrenk* (in Mo. Bot. Gard. Herb., 42864).

Colorado: Tolland, 8000–10000 ft. altitude, *F. J. Seaver & E. Bethel* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 42761).

Montana: comm. by E. L. Jensen, 6 (in Mo. Bot. Gard. Herb., 10362); Evaro, *J. R. Weir, 430, 417, 418* (in Mo. Bot. Gard. Herb., 3469, 14771, 14769); Missoula, *J. R. Weir, 433, 429* (in Mo. Bot. Gard. Herb., 3917, 13019).

Idaho: Priest River, *J. R. Weir, 94, 89, 100, 101* (in Mo. Bot. Gard. Herb., 8153, 12554, 15945, 15835), and *18.*

Alaska: Sitka, *W. Trelease, 583a* (in Mo. Bot. Gard. Herb., 5168).

British Columbia: Hastings, *J. Macoun, 63;* Kootenai Mts., near Salmo, *J. R. Weir, 514* (in Mo. Bot. Gard. Herb., 1740); Sidney, *J. Macoun, 38, 68, 76* (in Mo. Bot. Gard. Herb., 6688, 55366, 55367).

Washington: Bingen, *W. N. Suksdorf, 686, 691, 718, 743, 746, 873;* Bainbridge Island, *E. Bartholomew,* in Bartholomew, Fungi Col., 3134; Kalama, *C. J. Humphrey, 6163, 6201;* Seattle, *W. A. Murrill, 123,* and *an unnumbered specimen* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55530, 55531).

Oregon: Blue Mts., *C. L. Shear, 789, 796;* Corvallis, *C. E. Owens, 2082, 2138* (in Mo. Bot. Gard. Herb., 44248, 44698); Philomath, *G. B. Posey,* comm. by C. E. Owens, 2058 (in

Mo. Bot. Gard. Herb., 43879); Wallowa Lake, *C. L. Shear, 790, 792, 794.*

California: *R. A. Harper, 129* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55532); Ferndale, *S. C. Edwards* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55533); Mt. Tamalpais, Marion Co., *W. A. Setchell & C. C. Dobie, 1026* (in Mo. Bot. Gard. Herb., 44240); Muir Woods, *R. A. Harper* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55534); Palo Alto, *W. A. Murrill & L. S. Abrams, 1290* (in N. Y. Bot. Gard. Herb.); San Mateo Mts., *E. B. Copeland,* comm. by C. F. Baker, 1800, and (in Mo. Bot. Gard. Herb., 5173).

Mexico: Jalapa, 5000 ft. altitude, *W. A. & Edna L. Murrill, 118, 119* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 10925, 10747).

12. H. badio-ferruginea (Mont.) Léveillé, Ann. Sci. Nat. Bot. III. **5**: 152. 1846; Cooke, Grevillea **8**: 146. 1880; Sacc. Syll. Fung. **6**: 591. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 101. 1890.

Stereum badio-ferrugineum Montagne, Ann. Sci. Nat. Bot. II. **20**: 367. 1843; Syll. Crypt. 178. 1856.

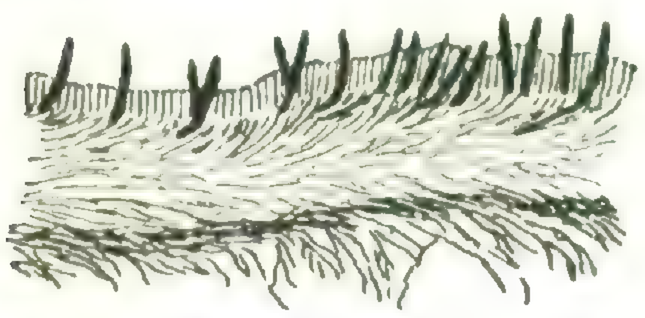


Fig. 10
H. badio-ferruginea.
Section × 68. From authentic specimen.
See *pl. 16, f. 4.*

Type: in Museum of Paris Herb., according to Léveillé, *loc. cit.;* authentic specimen of later collection from Montagne to Berkeley, in Kew Herb.

Fructifications imbricated, conchiform, umbonate-sessile or reflexed, thin, drying pliant, with the upper surface sericeous, lineate-radiate, Sayal-brown when young, becoming variegated with concentric, glabrous, bay or chestnut-brown zones; hymenium snuff-brown, sometimes minutely cracked; in structure 200–300 μ thick, with a dark, dense, subhymenial zone and with the hyphal layer composed of a broad intermediate layer of longitudinally arranged, golden-yellow hyphae $3\frac{1}{2}$ μ in diameter, connected with the loosely arranged

hyphae of the upper surface of the pileus by a narrow, dark, dense zone; setae cylindric below, acute, 50–75×8–10 μ, emerging up to 50 μ, starting from various parts of the dark subhymenial zone, abundant but not crowded; spores hyaline, even, somewhat curved, 4–6×1–2 μ, as seen in preparations of sections.

Fructifications with pilei 4–7 mm. long, 4–10 mm. broad, sometimes laterally confluent; resupinate portions, when present, ½–2×2½–7½ cm.

On erect rotting stumps of frondose species—rarely on prostrate logs. Canada to Carolina. June to January. Occasional.

This species is so closely related to *H. tabacina* that I have been doubtful whether it is not a form of the latter somewhat modified in form of fructifications through growing on a vertical surface. *H. badio-ferruginea* may be separated from *H. tabacina* by growing upon a vertical surface and by the small imbricated, conchiform pilei which are thinner than those of *H. tabacina,* and by the hymenium either not at all cracked or with narrow cracks which do not form systems radiating from several centers in the resupinate portion—each system of cracks from its own center. The type of *H. badio-ferruginea* was collected in New York by Menand. All European specimens of *H. tabacina* which I have seen are distinct also from *H. badio-ferruginea* in the characters enumerated above.

Specimens examined:

Canada: Bushwood, *J. Macoun, 115.*

New Brunswick: Tobique River, *G. N. Hay.*

Maine: Piscataquis County, *W. A. Murrill, 1941, 2232, 2246, 2248* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55515–55518); Penobscot County, *W. A. Murrill, 1807* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55506).

New Hampshire: *P. Wilson* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55519); Camp, Ellis R., *U. & C.,* from Underwood Coll., 8 (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55502); White Mts., *U. & C., 19,*

32, from Underwood Coll. (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55520, 55521).

Vermont: Middlebury, *E. A. Burt.*

New York: Adirondacks, *G. F. Atkinson, a;* East Galway, *E. A. Burt,* two collections; Floodwood, *E. A. Burt.*

New Jersey: Lakewood, *E. A. Daniels,* comm. by H. Webster.

Carolina: specimen determined by Montagne (in Kew Herb.).

13. H. rubiginosa Dickson ex Léveillé, Ann. Sci. Nat. Bot. III. **5** : 151. 1846; Cooke, Grevillea **8** : 145. 1880; Sacc. Syll. Fung. **6** : 589. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 97. 1890; Brown, Mycologia **7** : 1. *pl. 149–151.* 1915.

Helvella rubiginosa Dickson, Fasc. Pl. Crypt. Brit. 1 : 20. 1785; Sowerby, Brit. Fungi, *pl. 26.* 1796.—*Thelephora rubiginosa* Schrader, Spic. Fl. Germ. 185. 1794; Persoon, Syn. Fung. 567. 1801; Myc. Eur. **1** : 120. 1822; Fries, Syst. Myc. **1** : 436. 1821.—*Stereum rubiginosum* Fries, Epicr. 550. 1838; Hym. Eur. 641. 1874.—*Auricularia ferruginea* Bulliard, Herb. de la France **2** : 281. *pl. 378.* 1787; Sowerby, Brit. Fungi, *pl. 26.* 1796.—*Stereum ferrugineum* Bulliard ex Fries, Epicr. 550. 1838; Hym. Eur. 640. 1874; Sacc. Syll. Fung. **6** : 565. 1888. —*Hymenochaete ferruginea* (Bulliard) Massee, Linn. Soc. Bot. Jour. **27** : 103. 1890; Bresadola, I. R. Accad. Agiati Atti III. **3** : 109. 1897.

Illustrations: Bulliard, Herb. de la France, *pl. 378;* Fl. Danica, *pl. 1619. f. 2;* Sowerby, Brit. Fungi, *pl. 26;* Rabenhorst, Krypt.-Fl. **1** : 320. *f. 1;* Brown, Mycologia **7** : *pl. 149–151.*

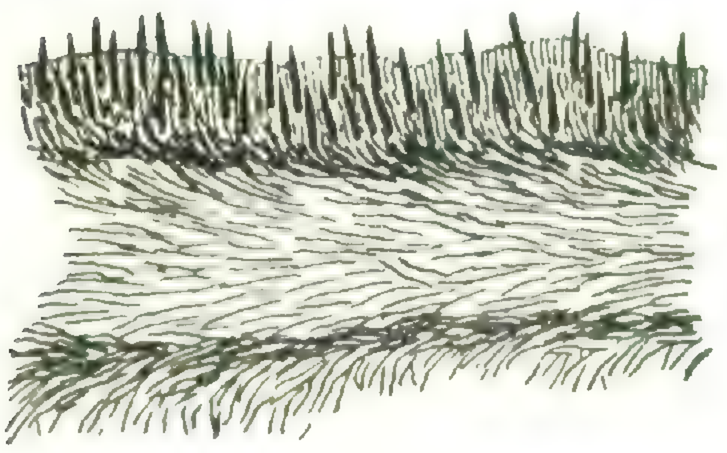


Fig. 11
H. rubiginosa.
Section × 68. See *pl. 17, f. 14.*

Fructifications coriaceous-rigid, effused, reflexed, or sometimes wholly resupinate, separable, somewhat fasciate above, concentrically sulcate, velvety, Brussels-brown, finally glabrous, fuscous-black, the margin ochraceous-tawny; hymenium conspicuously setulose under a lens, somewhat colliculose, bister; in structure 500–700 μ thick, with the broad, dense, dark, setigerous layer 160 μ thick and with the intermediate layer

composed of longitudinally arranged, colored hyphae 2½ μ in diameter and bordered above by a narrow, dense, dark zone; setae very numerous, slightly curved, tapering upward to a very sharp point, 50–60×5–6 μ, emerging up to 45 μ, starting from all parts of the setigerous layer; spores hyaline, even, 4–6×2–3 μ.

Fructifications with reflexed portion 1–2½ cm. long, 1–3 cm. broad and sometimes larger by lateral confluence; resupinate portion 7–8×1–3 cm.

On decaying logs and stumps of oak and other frondose species. Canada to Mexico, westward to Oregon and California, and in Porto Rico. July to February, persisting to June. Common.

H. rubiginosa may be recognized by its rigid pileus, velvety, concentrically sulcate, and Brussels-brown (rubiginous) in color, by the colliculose, bister hymenium whose dark red component color and setae show to advantage in reflected light, and by the brighter ochraceous margin. Even resupinate specimens may be recognized at sight by being separable from the substratum, and by the form and color of the hymenium and the contrasting bright margin. The structure in section is equally constant and distinctive. This species produces a pocketed heart rot in oak wood.

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 3133; Berkeley, Brit. Fungi, 247; Ellis, N. Am. Fungi, 327; Kunze, Fungi Sel., 203; Rabenhorst, Herb. Myc., 212.

England: in Berkeley, Brit. Fungi, 247; Kenilworth, *W. A. Murrill* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55542).

Sweden: Upsala, *E. Fries,* det. by Fries as *Stereum ferrugineum,* comm. by L. Romell, 27; Femsjö, *L. Romell, 35;* Halland, *L. Romell, 36;* Lapland, *L. Romell, 396, 397.*

Germany: *J. Kunze,* in Kunze, Fungi Sel., 203 (in Mo. Bot. Gard. Herb., 44098); from Persoon, under the name *Thelephora rubiginosa* (in Kew Herb.); Dresden, in Rabenhorst, Herb. Myc., 212.

Austria-Hungary: Löcse, *V. Greschick,* comm. by Bresadola, under the name *Hymenochaete ferruginea.*

Canada: *J. Macoun, 92;* Lower St. Lawrence Valley, *J. Macoun, 63;* London, Ontario, *J. Dearness, 981* (in N. Y. Bot. Gard. Herb.).

Maine: Orono (in N. Y. Bot. Gard. Herb.).

Vermont: Lake Dunmore, *E. A. Burt,* two collections; Middlebury, *E. A. Burt,* two collections.

Massachusetts: Webster, *R. G. Leavitt.*

Connecticut: *V. S. White* (in N. Y. Bot. Gard. Herb.); Central Village, *J. L. Sheldon, 25,* comm. by N. Y. Bot. Gard. Herb.; Redding, *F. S. Earle, 455,* and *Underwood & Earle, 498* (both in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55540, 55541).

New York: Alcove, *C. L. Shear, 241;* East Galway, *E. A. Burt,* five collections; Ithaca, *G. F. Atkinson, 22942, 22942a,* and *Van Hook,* comm. by G. F. Atkinson, A, and *H. P. Brown* (in Mo. Bot. Gard. Herb., 44099); Karner, *H. D. House* (in N. Y. State Mus. Herb., and in Mo. Bot. Gard. Herb., 54355); New Berlin, *W. H. Long, 19070* (in Mo. Bot. Gard. Herb., 44163); New York Botanic Garden, *Class in Mycology* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55543).

New Jersey: Fort Lee, *W. A. Murrill* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55545); Hackensack Swamp, *W. H. Ballou, 1.*

Pennsylvania: Bear Meadows, *A. S. Rhoads, 10* (in Mo. Bot. Gard. Herb., 44087); Kittanning, *D. R. Sumstine;* Ohio Pyle, *W. A. Murrill, 1087* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55546); Sayre, *W. C. Barbour, 1386* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55547); Spruce Creek, *J. H. Faull,* Univ. of Toronto Herb., 348 (in Mo. Bot. Gard. Herb., 44880); Trexlertown, *C. G. Lloyd, 0019, 0256;* West Chester, *Haines, Everhart & Jefferis,* in Ellis, N. Am. Fungi, 327.

Maryland: Takoma Park, *C. L. Shear, 1274.*

Virginia: Blacksburg, *Miss V. W. Murrill, 19* (in N. Y. Bot.

Gard. Herb., and in Mo. Bot. Gard. Herb., 55548); Woodstock, *C. L. Shear, 1192.*

North Carolina: comm. by W. H. Long, 12930, 19123 (in Mo. Bot. Gard. Herb., 44162, 44165); Blowing Rock, *G. F. Atkinson, 4030, 4188, 4309, 4310, 4312, 4321;* Pink Bed Valley, Transylvania Co., *W. A. Murrill & H. D. House, 422* (in N. Y. Bot. Gard. Herb.).

Florida: *C. G. Lloyd, 4858.*

Alabama: Montgomery, *R. P. Burke, 149* (in Mo. Bot. Gard. Herb., 44905).

Louisiana: Bogalusa, *C. J. Humphrey, 5499* (in Mo. Bot. Gard. Herb., 13613); St. Martinville, *A. B. Langlois.*

Ohio: *C. G. Lloyd, 3910;* Cincinnati, *A. P. Morgan,* comm. by Lloyd Herb., 2636, and *C. G. Lloyd, 4527;* Linwood, *C. G. Lloyd* (in Lloyd Herb., 07374, and in Mo. Bot. Gard. Herb., 55554); Miami Valley, *A. P. Morgan* (in Mo. Bot. Gard. Herb., 5177).

West Virginia: Eglon, *C. G. Lloyd, 02714;* Morgantown, *J. L. Sheldon, 3537,* comm. by N. Y. Bot. Gard. Herb.

Tennessee: Elkmont, *C. H. Kauffman, 75* (in Mo. Bot. Gard. Herb., 21462).

Indiana: Crawfordsville, *D. Reddick, 1, 16;* Lafayette, *C. R. Orton, 6* (in Mo. Bot. Gard. Herb., 44083).

Illinois: River Forest, *E. T. & S. A. Harper, 630.*

Wisconsin: Blue Mounds, Univ. of Wisconsin Herb., 24; Madison (in Mo. Bot. Gard. Herb., 4996).

Missouri: Creve Coeur, *E. A. Burt* (in Mo. Bot. Gard. Herb., 10405), and *P. Spaulding* (in Mo. Bot. Gard. Herb., 44097); Upper Creve Coeur, *E. A. Burt* (in Mo. Bot. Gard. Herb., 44048).

Arkansas: Cass, *W. H. Long, 19806* (in Mo. Bot. Gard. Herb., 8966).

Nebraska: Saltillo, *C. L. Shear, 1093.*

Kansas: Emporia, *E. Bartholomew,* in Bartholomew, Fungi Col., 3133.

Arizona: Santa Catalina Mts., *G. G. Hedgcock & W. H. Long,* comm. by C. J. Humphrey, 2507 (in Mo. Bot. Gard. Herb., 42934).

Oregon: Corvallis, *C. E. Owens, 2137, 2148* (in Mo. Bot. Gard. Herb., 44696, 9187).
California: Palo Alto, *W. A. Murrill & L. S. Abrams, 1161* (in N. Y. Bot. Gard. Herb.).
Mexico: Guernavaca, *W. A. & Edna L. Murrill, 406* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54533).
Porto Rico: El Duque, *J. A. Stevenson & J. R. Johnston, 1487* (in Mo. Bot. Gard. Herb., 6597); Rio Piedras, *J. A. Stevenson & R. C. Rose,* comm. by J. A. Stevenson, 6514 (in Mo. Bot. Gard. Herb., 55088).

14. H. reflexa Burt, n. sp.

Type: in Burt Herb. and N. Y. Bot. Gard. Herb.

Fructifications effused, broadly reflexed, thin, rigid, fibrillose, Prout's brown, finally glabrous, shallowly concentrically sulcate and zonate, with obscure blackish zones in the furrows; hymenium even, not cracked, Sudan-brown; in structure 500–600 μ thick, composed of a zonate setigerous layer 300–400 μ thick and of an intermediate layer bordered on the upper side by a dense, but not dark, zone which connects with the more loosely arranged hyphae of the upper surface of the pileus; setigerous layer very compact, composed of crowded, erect hyphae, between which are scattered, slender setae, slightly curved, sharp-pointed, 35–40× 4½–5 μ, emerging up to 30 μ, present in all parts of the layer; hyphae of intermediate layer densely, longitudinally arranged, colored, 2½ μ in diameter; no spores found.

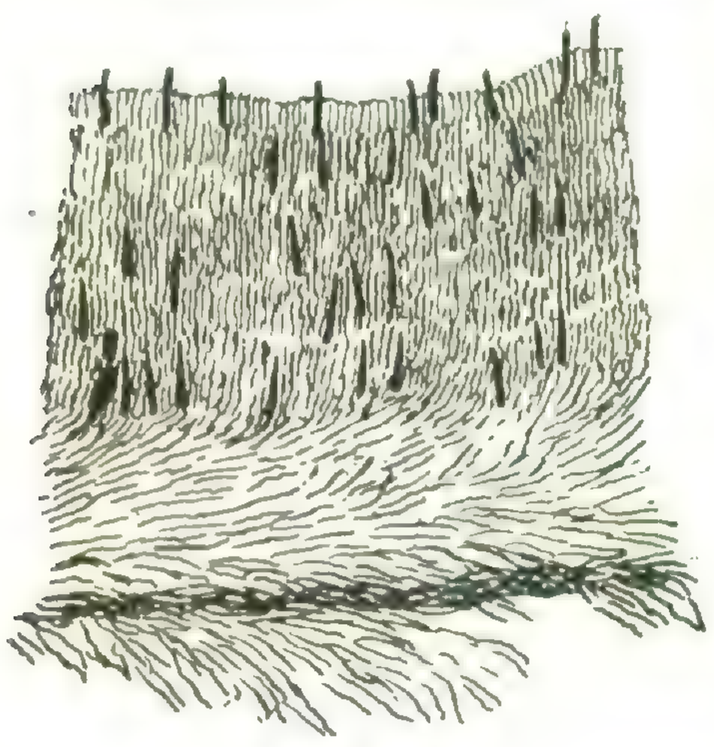


Fig. 12
H. reflexa.
Section × 68. From type.
See *pl. 17, f. 13.*

Fructification with reflexed portion 2 cm. long, about 8 cm. broad; resupinate strip 3 mm. across at base of reflexed portion is all of resupinate portion which was collected.

Under side of decaying wood. Jamaica. January. Rare.

H. reflexa bears some resemblance to *H. rubiginosa* in its rigid and dark-colored pileus; a similar resemblance to *H.*

rubiginosa was stated by Fries, Elenchus Fung. **1** : 174, in the comment of the original description of *Thelephora leprosa* collected in Brazil. If the specimen of *Thelephora leprosa* upon which Léveillé based his transfer of this species of *Hymenochaete* is still in the Museum of Paris Herbarium and is from the original collection, comparison with this specimen may show that *H. reflexa* should be regarded as a synonym of *T. leprosa.* The structure in section of *H. reflexa* is very like that of *H. unicolor,* but the hymenium is of different color and all the collections of *H. unicolor* have the margin closely adnate.

Specimens examined:

Jamaica: Troy and Tyre, *W. A. Murrill & W. Harris, 989,* type, comm. by N. Y. Bot. Gard. Herb.

15. H. cubensis Burt, n. sp.

Type: in Burt Herb. and N. Y. Bot. Gard. Herb.

Fructifications imbricated, flabelliform, dimidiate, umbonate-sessile and attached along one side, or effused and reflexed, thin, coriaceous, pliant when dry, minutely tomentose, concentrically sulcate, antique brown when young, becoming snuff-brown to Rood's brown; hymenium even, antique brown; in structure 300–400 μ thick, with a setigerous layer 80–100 μ broad and a narrow intermediate layer which is connected by a narrow, dark, dense zone with the loosely arranged hyphae of the upper surface of the pileus; setae not abundant, 35–45$\times$4½–6 μ, emerging up to 30μ, slender, somewhat falcate, sharp-pointed, occurring in all parts of the setigerous layer which contains many colored, amorphous grains also; hyphae of intermediate layer 2½–3 μ in diameter, colored; spores hyaline, even, 4–4½$\times$2 μ.

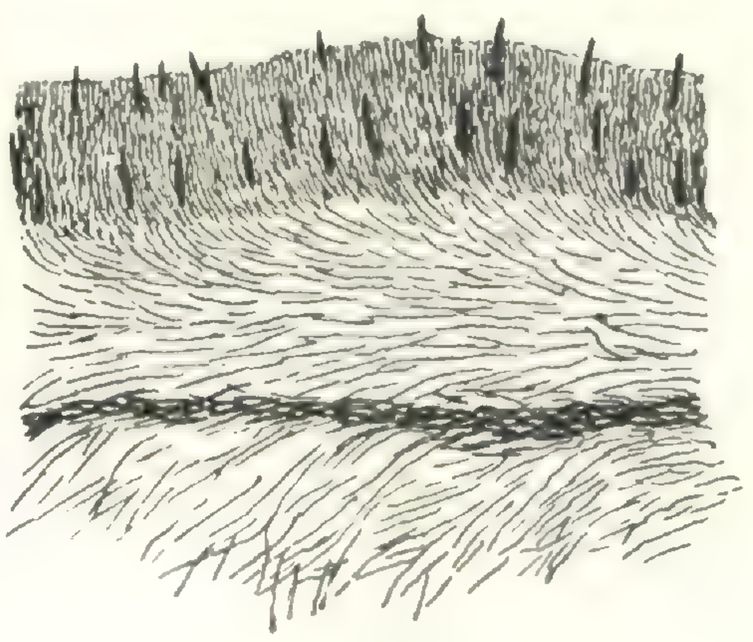


Fig. 13
H. cubensis.
Section $\times$ 68. From type.
See *pl. 17, f. 8.*

Fructifications 1 cm. from umbo to margin, or when dimidiate 1–2 cm. broad, 1–2 cm. long, and sometimes larger by

lateral confluence; resupinate portions about 2 cm. in diameter present in one collection.

On rotting frondose wood and logs in dense forests, causing a pocketed rot. Cuba and Porto Rico. February and March. Frequent.

H. cubensis is related to *H. reflexa* in structure, but its fructifications are smaller and thinner than those of the latter, and are nearly always umbonate-sessile or dimidiate—only very rarely reflexed—and do not become glabrous and dark-colored, with resemblance to *H. rubiginosa*. Such ample collections of *H. cubensis* have been made that it seems as though this species should have been described heretofore, but I have failed to find anything in earlier work to which these specimens may be referred.

Specimens examined:

Cuba: Alto Cedro, *L. M. Underwood & F. S. Earle, 1491*, type, and *1565*, and *Earle & Murrill, 456*, all comm. by N. Y. Bot. Gard. Herb.; La Gloria, Camagüey, *J. A. Shafer, 739* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55549); Managua, Havana Province, *Earle & Murrill, 21*, comm. by N. Y. Bot. Gard. Herb.

Porto Rico: Monte Cerrote, near Adjuntas, *N. L. Britton & S. Brown, 5479* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55550).

16. H. ungulata Burt, n. sp. Plate 17, fig. 17.

Type: in Mo. Bot. Gard. Herb. and N. Y. Bot. Gard. Herb.

Pileus very hard, tuberculate-ungulate, sessile, decurrent, triangular in section, with the upper surface black, crust-like, glabrous, the margin obtuse; hymenium oblique, pruinose, between white and pearl-gray; in structure 3 mm. thick, no intermediate layer found, composed of a setigerous layer 1 mm. or more thick, of layered structure, and of the stony pseudoparenchymatous crust; setae 75×9 μ, tapering from the base, very abundant, starting from all parts of the setigerous layer; no spores found.

Pileus 3 mm. long, 5–12 mm. wide, 2–3 mm. thick.

On bark of dead standing trunk or stump in virgin forest, 5000 ft. altitude. Mexico. December.

H. ungulata is unique in our species of this genus by its small, hoof-shaped fructifications with ashy white hymenium and crust-like, dull black upper surface. The fructifications are so hard that they turn the edge of the razor immediately in sectioning and have not afforded good preparations for showing the structure above the setigerous layer. *H. ungulata* probably belongs in the group with *H. corticolor*.

Specimens examined:

Mexico: Jalapa, *W. A. & Edna L. Murrill, 176,* type (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 44970).

17. **H. corticolor** Berk. & Ravenel, Grevillea **1** : 165. 1873; Cooke, Grevillea **8** : 147. 1880; Sacc. Syll. Fung. **6** : 595. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 111. 1890.

Type: type distribution in Ravenel, Fungi Car. **3** : 30.

Fructifications hard, woody, either wholly resupinate, adnate, and following the inequalities of the substratum, or with the upper edge thickened, barely reflexed, black, glabrous; hymenium drab, even; in structure 400–1000 μ thick, lacking an intermediate layer, with the setigerous layer constituting the whole thickness of the fructification and composed of densely arranged, suberect, interwoven, pale hyphae, much crystalline matter, and scattered setae; setae 60–75$\times$9 μ, emerging up to 45 μ, sharp-pointed, distributed in all parts of the fructification; spores hyaline, even, flattened on one side, $4\frac{1}{2}\times3\frac{1}{2}$ μ.

Fig. 14
H. corticolor.
Section $\times$ 44. From type.
See *pl. 16, f. 7.*

Resupinate over areas 1–3$\times$1$\frac{1}{2}$–5 cm., with reflexed margin 1–1$\frac{1}{2}$ mm. broad.

On bark, often in its crevices, of living trunks of oak, elm, *Magnolia,* and other frondose species. New Jersey to Florida, and in Cuba, Jamaica, and Grenada. Autumn to February.

The absence of an intermediate layer is likely to place the usual collections of resupinate *H. corticolor* in the group of species with *H. corrugata, H. cervina, H. Pellicula, H. tenuis,* etc., from all of which *H. corticolor* is distinguishable at sight by its great thickness, drab hymenium, black upper surface of reflexed edge, and occurrence on the bark of living tree trunks. This species attains its best development in South Carolina and Florida. The black upper surface of the reflexed edge is a good character for separation from *H. unicolor.*

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 408; Ravenel, Fungi Car. **3**: 30; Fungi Am., 121.

New Jersey: Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 408.

Maryland: Takoma Park, *C. L. Shear, 1003, 1096.*

South Carolina: *H. W. Ravenel,* Curtis Herb., 1553 (in Kew Herb.), and in Ravenel, Fungi Car. **3**: 30, type distribution.

Florida: Cocoanut Grove, *R. Thaxter, 79* (in Farlow Herb., and in Mo. Bot. Gard. Herb., 43984); Daytona, *R. Thaxter, 13* (in Farlow Herb., and in Mo. Bot. Gard. Herb., 43933); Gainesville, *N. L. T. Nelson* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55455), and *H. W. Ravenel,* in Ravenel, Fungi Am., 121.

Cuba: San Diego de los Baños, *Earle & Murrill, 198,* comm. by N. Y. Bot. Gard. Herb.

Jamaica: Cinchona, *W. A. & Edna L. Murrill, 419,* comm. by N. Y. Bot. Gard. Herb.

Grenada: Grand Etang, *R. Thaxter,* comm. by W. G. Farlow, 13.

18. H. arida Karsten in Sacc. Syll. Fung. **9**: 228. 1891; Bresadola, Ann. Myc. **1**: 93. 1903.

Hymenochaetella arida Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 428. 1889.—*H. laxa* Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 429. 1889.—*Hymenochaete laxa* Karsten in Sacc. Syll. Fung. **9**: 228. 1891.—*Corticium simulans* Berk. & Rav. in Cooke, Grevillea **6**: 132. 1878 (without description but with reference to Ravenel, Fungi Am., 10); Ravenel, Fungi Car. **5**: 25 (without description); de

Thümen, Myc. Univ., 512 (without description).—Probably not *Corticium simulans* Berk. & Broome, Linn. Soc. Bot. Jour. **14**: 72. 1873.—*Hymenochaete simulans* (Berk. & Rav.) Peck, N. Y. State Mus. Rept. **49**: 34. 1897 (without description); v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. **116**: 775. 1907.

Type: authentic specimen from Karsten in Burt Herb.

Fructifications resupinate, effused, scattered, orbicular at first, then laterally confluent, thin, dry, adnate, not cracked, drying clay-color to antique brown, the margin thinning out; in structure 100–140 μ thick, composed of loosely interwoven, suberect hyphae 3–4 μ in diameter, colored like the fructification, stiff, not nodose-septate, forming a homogeneous layer, without a dense zone from substratum to hymenium, and bearing scattered setae in the upper portion of the layer; setae 30–75×6–8 μ, emerging up to 35 μ, not numerous, tapering upward; spores in spore collection from Swedish specimen white, even, allantoid, 6–7×2 μ as seen in side view, 2½–3 μ broad in front view, and 6–7×3½–4 μ, flattened on one side in American specimens.

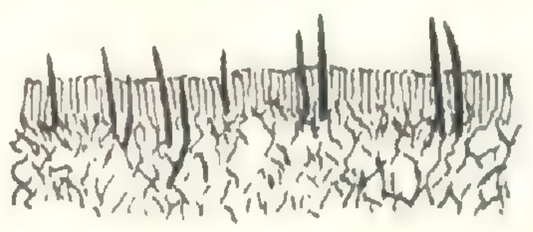


Fig. 15
H. arida.
Section ×68. From authentic specimen.

Fructifications at first 2–3×2 mm., later laterally confluent over areas 9×1–1½ cm.

On bark of dead branches of *Corylus, Ostrya virginica,* and *Vaccinium arboreum.* Finland, Sweden, Vermont to South Carolina, and in Michigan. October to April.

The fructifications of *H. arida* are at first small, scattered, and suborbicular and later become confluent and elongated so as to resemble closely in aspect and color *Coniophora arida.* The spores of American collections are about twice the breadth of those of European specimens cited, but the agreement between the European and American specimens is so close in general aspect and in the very simple structure of the fructification in section that I believe the American and European specimens are of the same species. The distinguishing characters of *H. arida* are its resemblance in aspect to *Coniophora arida,* structure consisting of a single, homo-

geneous layer of loosely interwoven, suberect hyphae, with setae distributed in outer half of the layer, rather large spores, and the occurrence in the United States upon bark of *Ostrya* and *Vaccinium arboreum*. Von Höhnel and Litschauer in their notes on types in Karsten's herbarium[1] referred *Hymenochaete arida* and *H. laxa* to *H. unicolor* and *H. cinnamomea* respectively — species with which they have nothing in common except color.

Specimens examined:

Exsiccati: Ravenel, Fungi Car. **5**:25; Fungi Am., 10; de Thümen, Myc. Univ., 512.—in each under the name *Corticium simulans* B. & Rav.

Finland: Mustiala, *P. A. Karsten,* authentic specimen and another specimen communicated by Bresadola; Runsala, *P. A. Karsten,* authentic specimen of *Hymenochaetella laxa.*

Sweden: Upsala, *C. G. Lloyd, 08425* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55472).

Vermont: Middlebury, *E. A. Burt.*

New York: Fort Ann, *S. H. Burnham, 41* (in Mo. Bot. Gard. Herb., 54456).

South Carolina: Aiken, *H. W. Ravenel,* in Ravenel, Fungi Car. **5**:25, Fungi Am., 10, and in de Thümen, Myc. Univ., 512.

Michigan: Ann Arbor, *C. H. Kauffman, 32.*

19. H. unicolor Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 335. 1868; Cooke, Grevillea **8**:148. 1880; Sacc. Syll. Fung. **6**:597. 1888; Massee, Linn. Soc. Bot. Jour. **27**:108. 1890; Lloyd, Myc. Notes 41:572. *text f. 780, 781.* 1916.

H. fuliginosa Berk. & Curtis, Linn. Soc. Bot. Jour. **10**:335. 1868; not *H. fuliginosa* (Pers.) Lév.

Type: in Kew Herb.

Fructification resupinate, long and broadly effused, adnate, dense, cracked, brittle, scaling off from the wood, drying antique brown; in structure 500–700 μ thick, composed of a very thick, somewhat zonate, setigerous layer and of a thin hyphal layer which is often not sharply distinguishable from the setigerous layer; hyphae $2\frac{1}{2}$–3 μ in diameter; setae scat-

[1] K. Akad. Wiss. Wien Sitzungsber. 115: 1577, 1578. 1906.

tered in all parts of the setigerous layer, sometimes slightly falcate, 50–60×5–6 μ, emerging up to 40 μ, tapering from the base to a slender and sharp apex; basidia with 4 sterigmata; spores in spore collection white, even, 5–5½×3½–4 μ; causing pocketed rot in decorticated hard wood.

Covering decorticated poles 20 feet long.

On dead frondose wood. Cuba, Venezuela, and Brazil. December to April.

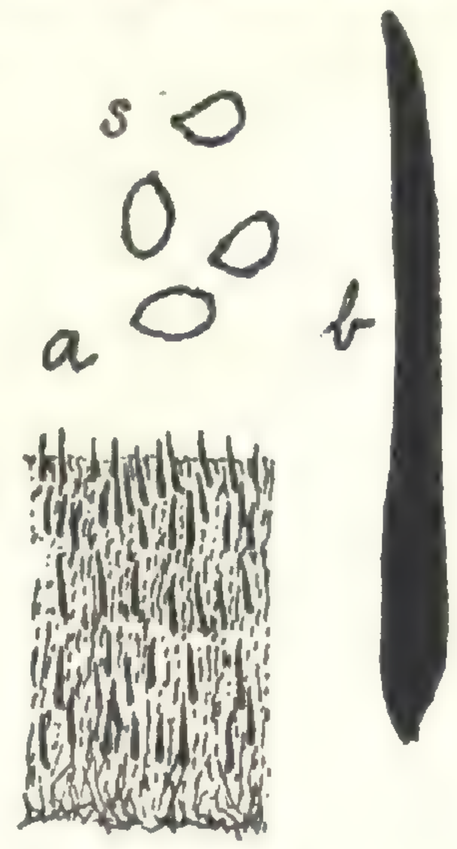


Fig. 16
H. unicolor.
Section, *a*, × 44; seta, *b*, and spores, *s*, × 850.

H. unicolor has the coloration and general aspect of *H. cinnamomea* and *H. spreta* but is usually rimose in contrast with the former and with a more velvety hymenium than the latter and is of a very dense structure with its hyphae arranged parallel with the rather uniformly distributed setae, while *H. cinnamomea* and *H. spreta* are stratose, with alternating layers of loosely interwoven hyphae separating the two or more hymenial layers. The dry rot produced in the wood by *H. unicolor* is a pocketed rot, as shown by the fine collection by Lloyd and well shown in his fig. 781, cited above, while the rot produced by *H. spreta* is a soft, fibrous sap rot which attacks the sap-wood uniformly from the outer surface. The specimen referred by Berkeley and Curtis to *H. fuliginosa,* collected in Cuba, *C. Wright, 188,* differs so slightly from the type of *H. unicolor* that it will probably be included in *H. unicolor* when better known by other collections.

Specimens examined:

Cuba: *C. Wright, 541,* type (in Kew Herb.) and *an unnumbered collection of 1857,* under the name of *H. cinnamomea* (in Curtis Herb.), and *188,* under the name *Hymenochaete fuliginosa* (in Kew Herb.); *C. G. Lloyd, 142, 171* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55458, 55473); Ceballos, *C. J. Humphrey, 2585, 2590, 2696, 2829, 2964* (in Mo. Bot. Gard. Herb., 16043, 16052, 1778, 14838, 1766).

Jamaica: Troy and Tyre, *W. A. Murrill & W. Harris, 991,* comm. by N. Y. Bot. Gard. Herb.

Venezuela: Margarita, *A. F. Blakeslee,* comm. by W. G. Farlow.

Brazil: Blumenau, *A. Möller,* comm. by J. Bresadola, under the name *Hymenochaete fuliginosa,* as listed in Hedwigia **35** : 289. 1896.

20. **H. agglutinans** Ellis, Torr. Bot. Club Bul. **5** : 46. 1874; Sacc. Syll. Fung. **6** : 602. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 106. 1890; Graves, Mycologia **6** : 279. *pl. 145.* 1914.

Hymenochaete ambiens Berk. & Curtis in Cooke, Grevillea **8** : 147. 1880; Sacc. Syll. Fung. **6** : 596. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 106. 1890.

Type: probably in N. Y. Bot. Gard. Herb.

Fructifications resupinate, effused, adnate, orbicular, at first of loose texture and cream-buff, then thick, very compact, concentrically sulcate, and antique brown, with the margin thick, determinate, and cream-buff, finally becoming black during the winter, infecting living limbs where they rub together and finally uniting them firmly; in structure 1–2 mm. thick, composed of a single homogeneous hyphal layer of densely interwoven, thick-walled hyphae concolorous with the fructification and bearing at the outer surface of this layer an opaque subhymenium upon which the setae stand; setae 70–90×9 μ, protruding 60 μ, few, scattered, starting from the subhymenium; basidia and spores not found.

Fructifications 3–7 cm. in diameter, 1–2 mm. thick.

Infecting living branches of *Almus, Benzoin, Acer,* etc., where they rub together. August to April. New Hampshire to Florida, westward to Idaho, and in Cuba. Frequent.

This species is easily recognized by its remarkable habit of joining together branches which have rubbed together and formed areas for infection. From these areas the fructification spreads so as to often encircle one or both limbs, at the same time killing the portions of the limbs beyond the fructification, as described by Graves in his article cited above.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 939; Ell. & Ev., Fungi Col., 807; de Thümen, Myc. Univ., 309.

New Hampshire: Chocorua, *W. G. Farlow.*
Vermont: Lost Pleiad Pond, Ripton, *E. A. Burt;* Middlebury, *E. A. Burt.*
Massachusetts: Cherry Brook, Weston, *A. B. Seymour, T 4* (in Mo. Bot. Gard. Herb., 43888); Magnolia, *W. G. Farlow;* Sharon, *A. P. D. Piguet,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 55475); Waltham, *A. B. Seymour, T 5* (in Mo. Bot. Gard. Herb., 43889).
Connecticut: Storrs, *A. E. Moss,* comm. by P. W. Graff, 39 (in Mo. Bot. Gard. Herb., 44791).
New York: Albany, *C. G. Lloyd, 07112* (in Lloyd Herb.); Alcove, *C. L. Shear, 999;* Brooklyn, *F. H. Ames* (in Lloyd Herb., 438); Chappaqua, *Mrs. C. E. Ryder & Mrs. W. A. Murrill* (in N. Y. Bot. Gard. Herb.); Ithaca, *G. F. Atkinson, 2022;* Scarsdale, *Mrs. Livingston & Miss Crane,* comm. by N. Y. Bot. Gard. Herb.
New Jersey: *C. F. Austin, 57* (in Curtis Herb. as an undetermined *Corticium* and in Kew Herb. as the type of *Hymenochaete ambiens* Berk. & Curtis); Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 939, in Ell. & Ev., Fungi Col., 807, and in de Thümen, Myc. Univ., 309.
Pennsylvania: Trexlertown, *W. Herbst, 1.*
North Carolina: Biltmore Estate, *W. A. Murrill* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55477).
Florida: Sorrento, *R. Thaxter, 74* (in Farlow Herb., and in Mo. Bot. Gard. Herb., 43896).
Ohio: Linwood, *C. G. Lloyd, 1879.*
Wisconsin: Madeline Island, near Bayfield, *V. B. Walker, 4* (in Mo. Bot. Gard. Herb., 6631).
Idaho: Priest River, *J. R. Weir, 345* (in Mo. Bot. Gard. Herb., 6853).
Cuba: Alto Cedro, Santiago, *F. S. Earle, 346,* from Herb. de Cuba Estacion Central Agronomica.

21. H. cinnamomea (Pers.) Bresadola, I. R. Accad. Agiati Atti III. **3**: 110. 1897.

Thelephora cinnamomea Persoon, Myc. Eur. **1**: 141. 1822; Fries, Elenchus Fung. **1**: 201. 1828.—*Corticium cinnamomeum*

(Pers.) Fries, Epicr. 561. 1838; Hym. Eur. 650. 1874.—*Hymenochaetella rudis* Karsten, Hedwigia **35**: 173. 1896.—*Hymenochaete rudis* Karsten in Sacc. Syll. Fung. **14**: 218. 1899.

Type: specimen determined by Fries in Herb. Fries.

Fructification resupinate, widely effused, adnate, velvety, not cracked, drying antique brown to Brussels-brown, the margin tomentose-fibrillose; in structure becoming 500–1000 μ thick, stratose, ranging up to 6 strata, each composed of a setigerous layer 30–45 μ broad and of a hyphal layer of equal or greater breadth, with hyphae colored like the fructification, loosely interwoven, 3 μ in diameter; setae 60–90×5–6 μ, protruding up to 60 μ, tapering upward from the base, originating in all parts of the setigerous layers; spores hyaline, even, $4\frac{1}{2}$–6×2–$2\frac{1}{2}$ μ as seen in sectional preparations, stated by Bresadola to be 6–9×$2\frac{1}{2}$ μ as obtained from spore collections.

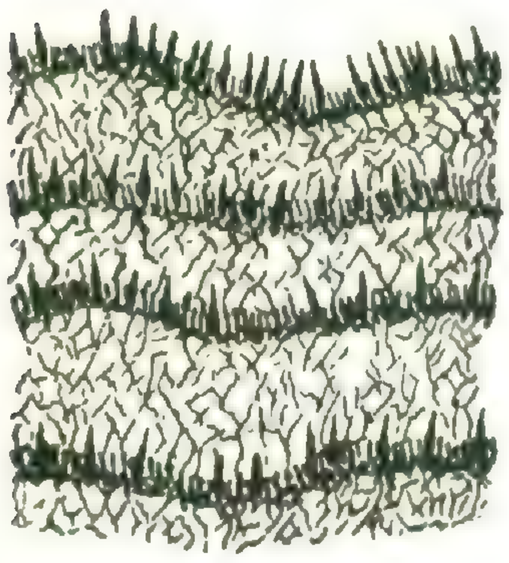


Fig. 17

H. cinnamomea.

Section × 44. From specimen in Herb. Fries.

Fructifications 3–7×$1\frac{1}{2}$–$2\frac{1}{2}$ cm.

On bark and decaying wood of both frondose and coniferous species but usually on the former. New York to California and British Columbia. June to April. Rare.

H. cinnamomea closely resembles in color and general aspect *Hypochnus ferrugineus* but is thicker and with a more compact hymenium. I base my idea of *H. cinnamomea* on the specimen from Norway determined by Fries and the fine specimens of identical structure collected in Lapland by Romell, in Finland by Karsten, and in Ardennes by Libert. The specimen from Hungary, received from Bresadola, has the same aspect, velvety, not cracked, and a thin surface setigerous layer but varies toward *H. spreta* by having its deeper setigerous layers more than 45 μ broad and exceeding the adjoining hyphal layers. This specimen from Bresadola formerly led me to regard *H. spreta* as a synonym of *H. cinnamomea* and to refer to *H. cinnamomea* for my correspond-

ents many specimens which will be found cited under *H. spreta*. *H. cinnamomea* appears clearly distinct from *H. spreta* by its velvety surface, not contracting greatly in thick specimens nor cracking to the substratum so as to form small, isolated, rectangular masses, by setigerous layers 30–45 μ broad and usually narrower than the adjoining hyphal layers, and spores up to 4½–9 μ long. Several of the American specimens cited below are first-stratum stages.

Specimens examined:

Exsiccati: Libert, Pl. Crypt. Arduennae, 122.

Norway: Christiania, *M. N. Blytt* (in Herb. Fries, det. by E. Fries).

Sweden: *L. Romell, 85,* first-stratum stage; Lapland, *L. Romell, 398, 399.*

Finland: Mustiala, *P. A. Karsten,* authentic specimen of *Hymenochaetella rudis.*

Hungary: *Kmet,* det. and comm. by J. Bresadola.

Belgium: in Libert, Pl. Crypt. Arduennae, 122.

New York: Staten Island, *W. H. Ballou* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55544).

Ohio: Cincinnati, *C. G. Lloyd, 4507.*

Illinois: Riverside, *E. T. & S. A. Harper, 657.*

Nebraska: Woodlawn, *C. L. Shear, 1026,* first-stratum stage.

Kansas: Rooks Co., *E. Bartholomew,* first-stratum stage.

California: Santa Barbara, *O. M. Oleson, 17,* first-stratum stage.

British Columbia: Sidney, *J. Macoun, 37, 99, 111* (in Mo. Bot. Gard. Herb., 6687, 55364, 55365). Nos. 37 and 111 are in the first-stratum stage.

22. H. digitata Burt, n. sp.

Type: in N. Y. Bot. Gard. Herb. and Mo. Bot. Gard. Herb.

Fructification resupinate, long and broadly effused, adnate, drying between Brussels-brown and antique brown, with hymenium somewhat granular, the margin determinate, very thin; in structure stratose, 800 μ thick, composed of about 15 narrow, loosely interwoven, hyphal layers alternating with the same number of very dense, dark and opaque setigerous layers

of about equal breadth and equal to the loosely interwoven layers; hyphae about 2 μ in diameter, concolorous with the fructification; setae 50–60×6 μ, emerging up to 50 μ, tapering from base to a sharp point, colored like the fructification; paraphyses colored like other organs, filiform, divided at the apex into about three short, finger-like branches or prongs; basidia and spores not found.

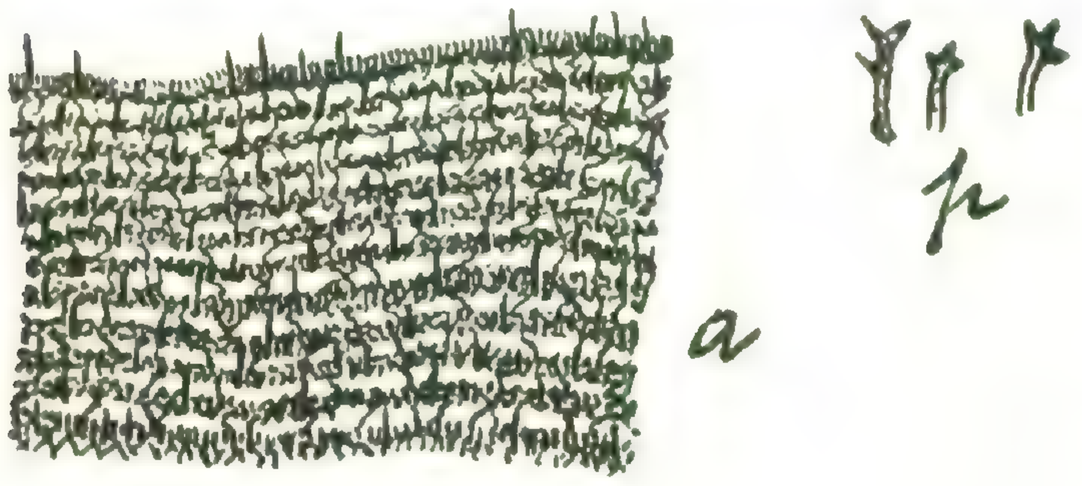


Fig. 18
H. digitata.
Section, *a*, ×44; paraphyses, *p*, ×500. From type.

Fructification 13×5 cm., broken off along three sides—probably large.

On bark of rotten logs in forests. Panama. March.

H. digitata belongs in the group of species with stratose fructifications, of which *H. spreta* is the best known. *H. digitata* should be easily recognized by its bright ferruginous brown color, fructification composed of very many and very narrow strata, and paraphyses with digitately, or sometimes pinnately, branched tips. Setae occur not only in the hymenial surface but also rather sparingly in the other setigerous layers throughout the fructification.

Specimens examined:

Panama: El Boquete, Chiriqui, *W. R. Maxon, 5559,* type, Smithsonian Survey of Panama Canal Zone (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55469).

23. H. spreta Peck, N. Y. State Mus. Rept. **30**: 47. 1879; Sacc. Syll. Fung. **6**: 595. 1888.

Hymenochaete laevigata Massee, Linn. Soc. Bot. Jour. **27**: 107. 1890.

Type: in N. Y. State Mus. Herb.

Fructifications resupinate, long and widely effused, adnate, rimose, drying Argus-brown to snuff-brown, the margin thinning out, velvety when young; in structure 300–500 μ thick,

stratose, composed of 1–3, or rarely up to 5, pairs of setigerous and hyphal layers, with the setigerous layers very dense, about 45–200 μ thick, exceeding the alternating hyphal layers which are composed of loosely interwoven, thick-walled, colored, even hyphae 3 μ in diameter; setae numerous, slender, subfalcate, 60–75×6 μ, originating at all levels in each setigerous layer, protruding up to 50 μ; spores hyaline, even, $4\frac{1}{2}\times2\frac{1}{2}$ μ.

Fructifications 4–25×2–10 cm.

Usually on decaying wood of frondose species, rarely on coniferous wood. Canada to Alabama and westward to Washington, California, and British Columbia. April to January. Common.

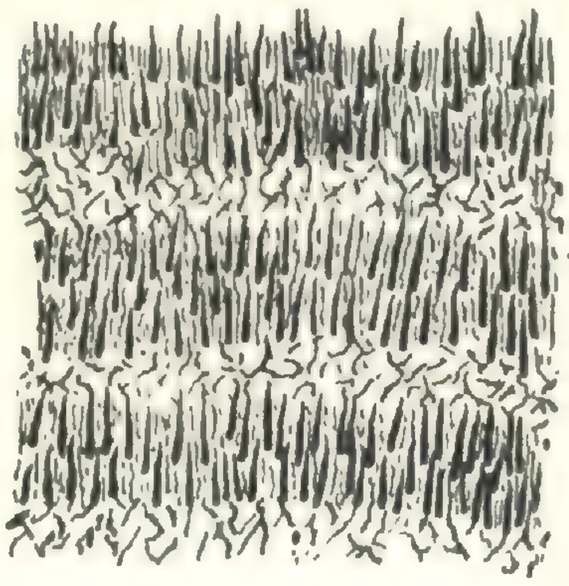


Fig. 19
H. spreta.
Section ×44. From type.

The stratose structure of well-developed fructifications of *H. spreta* locates this species in a small group of three species, of which the others are *H. digitata* and *H. cinnamomea*, from both of which thick fructifications of *H. spreta* may be separated readily by being deeply cracked and having setigerous layers from 45–150 μ, or rarely more, in thickness, very compact, and exceeding in thickness the adjoining, loosely interwoven hyphal layers. Fructifications of *H. spreta* in its first-stratum stage, consisting of but one hyphal layer and one setigerous layer, are frequently not cracked but have the setigerous layer 45 μ or more thick and thicker than the hyphal layer.

Specimens examined:

Exsiccati: Ell. & Ev., N. Am. Fungi, 1936, 3304 — the latter under the name *Hymenochaete unicolor;* Ell. & Ev., Fungi Col., 806, under the name *H. unicolor.*

Canada: Comox, Van Island, *J. Macoun, 18.*

Prince Edward's Island: *J. Macoun, 344.*

Ontario: London, *J. Dearness;* Ottawa, *J. Macoun, 6.*

New Hampshire: Chocorua, *W. G. Farlow,* two collections, one of which (in Mo. Bot. Gard. Herb., 55258).

Vermont: Middlebury, *C. G. Lloyd, 10671* (in Lloyd Herb.,

and in Mo. Bot. Gard. Herb., 55483), and *E. A. Burt,* four collections.

New York: Alcove, *C. L. Shear, 1310;* East Galway, *E. A. Burt;* Hudson Falls, *S. H. Burnham, 45* (in Mo. Bot. Gard. Herb., 54458); Ithaca, *G. F. Atkinson, 8656;* Karner, *H. D. House* (in N. Y. State Mus. Herb., 14.159, and in Mo. Bot. Gard. Herb., 44710); New York, *W. H. Ballou* (in Lloyd Herb., 12121, and in Mo. Bot. Gard. Herb., 55457).

New Jersey: Newfield, *J. B. Ellis* (in N. Y. Bot. Gard. Herb. and in Mo. Bot. Gard. Herb.).

Pennsylvania: Bethlehem, *Schweinitz* (in Herb. Schweinitz, under the name *Thelephora laevigata* and the type of *Hymenochaete laevigata* Massee).

District of Columbia: Takoma Park, *C. L. Shear, 1346.*

Georgia: Ribbon Brook, Tallulah Falls, *A. B. Seymour,* comm. by W. G. Farlow, EE (in Mo. Bot. Gard. Herb., 44603).

Florida: Cocoanut Grove, *R. Thaxter, 55* (in Farlow Herb., and in Mo. Bot. Gard. Herb., 43491); Nixon-Lewis Hammock, Dade Co., *J. K. Small & C. A. Mosier, 5396* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55485).

Alabama: Auburn, *F. S. Earle* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55486).

West Virginia: Eglon, *C. G. Lloyd, 1450, 1565* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55484 and 55488); Nuttallburg, *L. W. Nuttall,* in Ell. & Ev., N. Am. Fungi, 3304, and in Fungi Col., 806.

Ohio: Cincinnati, *A. P. Morgan,* comm. by C. G. Lloyd, 2610, and *C. G. Lloyd, 3578.*

Indiana: Crawfordsville, *D. Reddick, 15;* Millers, *E. T. & S. A. Harper, 934.*

Kentucky: Crittenden, *C. G. Lloyd, 07159, 10836* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55468 and 55487).

Montana: Evaro, *J. R. Weir, 422* (in Mo. Bot. Gard. Herb., 14766).

Idaho: Priest River, *J. R. Weir, 2.*

Washington: Bingen, *W. N. Suksdorf, 849;* Sedro-Woolley, *C. J. Humphrey, 7487* (in Mo. Bot. Gard. Herb., 10968);

Stanwood, *C. J. Humphrey, 6395, 7395* (in Mo. Bot. Gard. Herb., 42935 and 11042).

California: Palo Alto, *W. A. Murrill & L. S. Abrams, 1240* (in N. Y. Bot. Gard. Herb.).

British Columbia: *J. Macoun*, in Ell. & Ev., N. Am. Fungi, 1936; Kootenai Mts., near Salmo, *J. R. Weir, 494* (in Mo. Bot. Gard. Herb., 21796); Sidney, *J. Macoun, 79*, and *an unnumbered collection* (in Mo. Bot. Gard. Herb., 9967, 6687).

24. H. epichlora (Berk. & Curtis) Cooke, Grevillea **8** : 147. 1880; Sacc. Syll. Fung. **6** : 596. 1888.

Corticium epichlorum Berk. & Curtis, Grevillea **1** : 178. 1873; Massee, Linn. Soc. Bot. Jour. **27** : 119. 1890.—*Hymenochaete asperata* Ell. & Ev. Torr. Bot. Club Bul. **27** : 50. 1890; Sacc. Syll. Fung. **16** : 188. 1902.

Type: type distribution in Ravenel, Fungi Car. **5** : 24.

Fructification resupinate, broadly effused, thin, adnate, cracked, drying Isabella-color to tawny olive, with a thin olive-ocher subiculum forming a slight margin; in structure 75–120 μ thick, with the hyphal layer composed of loosely arranged, ascending, thin-walled hyphae $2\frac{1}{2}$ μ in diameter, colored like the fructification, in some places forming a narrow, dense zone next to the substratum; setae scattered, 36–45$\times$ $4\frac{1}{2}$–5 μ, protruding up to 30 μ, starting from different levels of the hymenium and subhymenium, tapering upward to a slender point; spores in spore collection white, even, 3–$4\frac{1}{2}\times$ 2–$2\frac{1}{2}$ μ, flattened on one side.

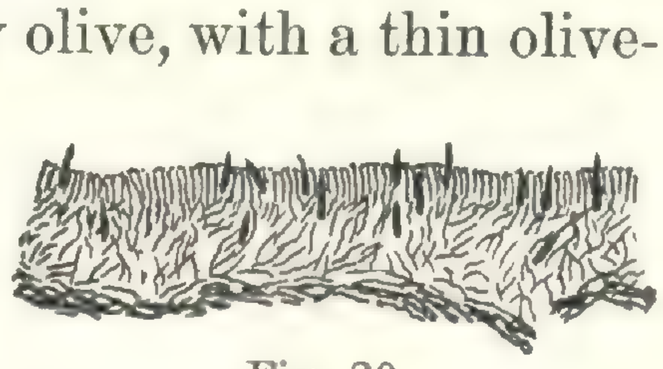


Fig. 20
H. epichlora.
Section × 68. From type.

Fructifications 5–10$\times$1–3 cm. and broken off at both ends —probably large.

On bark of dead *Symplocos, Vitis,* and other frondose woods. Alabama to Louisiana and in Mexico. August to November.

H. epichlora has some resemblance in aspect to *H. corrugata* on account of its cracked hymenial surface but it is dis-

tinguished from the latter species by the somewhat sulphur-yellow margin and subiculum which forms a broad hyphal layer destitute of setae between the subhymenium and the substratum; the spores of *H. epichlora* are shorter than those of *H. corrugata* and the setae are fewer and smaller.

Specimens examined:

Exsiccati: Ravenel, Fungi Car. **5** : 24, type distribution.

Alabama: *Peters, 6118* (in Kew Herb.), and in Ravenel, Fungi Car. **5** : 24.

Louisiana: Abita Springs, *A. B. Langlois, 2647 to Ellis*, type of *Hymenochaete asperata* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55491); Baton Rouge, *Edgerton & Humphrey*, comm. by C. J. Humphrey, 5727; St. Martinville, *A. B. Langlois, al, am.*

Mexico: Jalapa, *W. A. & Edna L. Murrill, 338, 344, 345* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 54480, 54460, and 54461).

25. H. dura Berk. & Curtis, Linn. Soc. Bot. Jour. **10** : 334. 1868; Cooke, Grevillea **8** : 147. 1880; Sacc. Syll. Fung. **6** : 596. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 105. 1890.

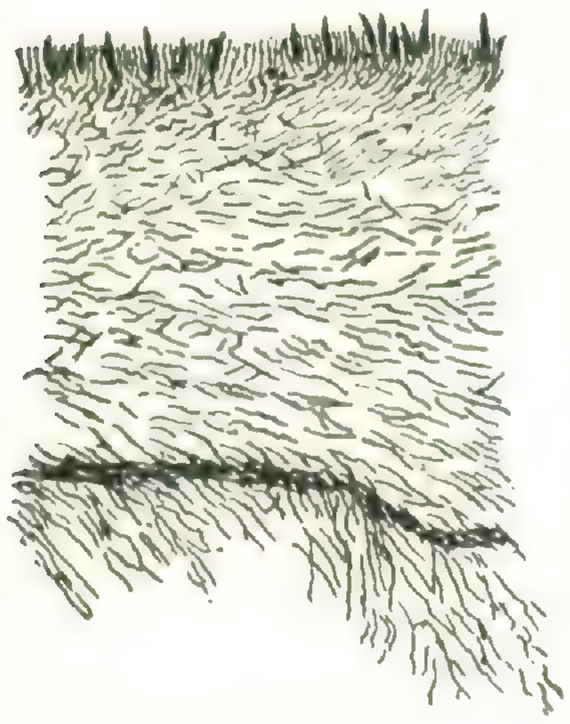


Fig. 21
H. dura.
Section ×68. From type.

Type: in Kew Herb. and Curtis Herb.

Fructifications resupinate, orbicular, rigid when dry, spongy when moistened, drying between wood-brown and Saccardo's umber, the margin thick, obtuse, paler than the hymenium; in structure 600–700 μ thick, with the intermediate layer bordered on each side by a narrow, dense, dark zone, that on the under side connecting the intermediate layer with a dense hyphal layer 100 μ broad, situated on the substratum; hyphae of intermediate layer baryta-yellow, 2 μ in diameter, longitudinally arranged, somewhat loosely interwoven; setae 30–36 ×5–6 μ, scattered between the hair-like paraphyses which they exceed but slightly, terminating in slender, curved, very

sharp-pointed tips, confined to the hymenium; spores hyaline, even, 5×3 μ.

Fructifications 1–3 cm. in diameter.

On dead, erect trees. Cuba. February. Rare.

In the original description, *H. dura* was said to be allied to *H. unicolor*, but if so, it is in aspect only, for when seen in section it is wholly different in structure from the latter, having a narrow setigerous layer and a broad, intermediate layer which is connected by a conspicuous dark zone with a well-developed hyphal layer next to the substratum. This structure in section places *H. dura* in the group with *H. tabacina*, from which, and from the other species of this group, it is distinct by its hairy hymenium and small, scattered setae.

Specimens examined:

Cuba: *C. Wright, 241,* type (in Kew Herb. and in Curtis Herb.).

26. H. leonina Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 334. 1868; Cooke, Grevillea **8**: 148. 1880; Sacc. Syll. Fung. **6**: 597. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 107. 1890.

Type: in Kew Herb. and Curtis Herb.

Fructifications r e s u p i n a t e, widely effused, thick, coriaceous, separable from substratum when moist, not cracked, drying tawny olive to Brussels-brown, the margin tomentose; in structure 200–700 μ thick, composed of (1) a compact setigerous layer 50–75 μ thick, with the setae starting at different levels within it, and of (2) a broad, supporting hyphal layer 100–600 μ thick, composed of loosely interwoven, rather longitudinally arranged hyphae 3 μ in diameter, stiff, colored like the fructification; in fully developed, thick fructifications the hyphal layer is divided parallel with the substratum by a narrow, dark zone; setae 60–80×7–9 μ, emerging up to 50 μ, conical, tapering from the base to the apex; spores hyaline, even, 5–6×3–3½ μ.

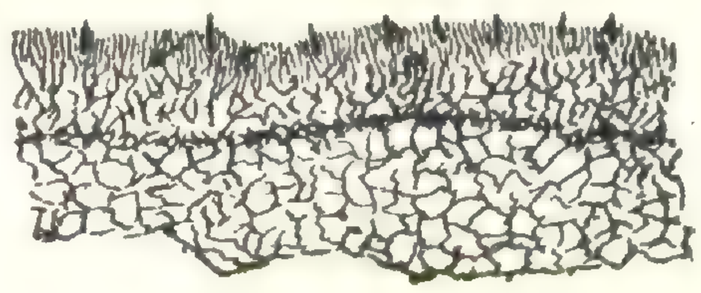


Fig. 22
H. leonina.
Section × 44. From type.

Probably large; small fructifications laterally confluent for 10 cm., 1–2 cm. broad; large fructifications 7 cm. in diameter and broken off on three sides.

On frondose limbs. Arkansas to Mexico, and in Cuba. August to March.

H. leonina has been resupinate in all collections which seem referable here by structure. The species is well marked by its usual tawny olive color, coriaceous structure which enables it to be dissected away from the substratum when moist, by the distribution of the setae in the hymenium and the dark, dense subhymenium, and by the broad, bright-colored hyphal layer which is finally divided in the middle by a narrow, dark zone.

Specimens examined:

Arkansas: Fordyce, *C. J. Humphrey, 5837.*

Louisiana: Baton Rouge, *C. J. Humphrey, 5691* (in Mo. Bot. Gard. Herb., 20707); St. Martinville, *A. B. Langlois, 2091, ai.*

Mexico: Vera Cruz, Sanborn, *C. R. Orcutt, 2920* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 37362).

Cuba: *C. Wright, 532,* type (in Kew Herb. and in Curtis Herb.); *C. G. Lloyd, 143* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55474); Alto Cedro, *Earle & Murrill, 505,* comm. by N. Y. Bot. Gard. Herb.; Baracoa, *Underwood & Earle, 780,* comm. by N. Y. Bot. Gard. Herb.; Pinar del Rio Province, *Earle & Murrill, 197,* comm. by N. Y. Bot. Gard. Herb.

27. H. fulva Burt, n. sp.

Type: in Burt Herb. and N. Y. Bot. Gard. Herb.

Fructifications resupinate, effused, thin, adnate, not cracking in drying, between Saccardo's umber and cinnamon-brown, the margin entire, determinate; in structure 120–260 μ thick, with the intermediate layer bordered on each side by a dark, dense zone—that on the under side directly adnate to the substratum and that on the other being subhymenial in position, 40–105 μ thick, bearing at first few setae but thickening with age and at length having many setae starting in all its parts; hyphae of intermediate layer colored, loosely interwoven, $2\frac{1}{2}$–3 μ in diameter; setae 75–90$\times$$7\frac{1}{2}$–9 μ, emerg-

ing up to 60 μ, not crowded, starting in the dark subhymenial zone and rising through the hymenium, tapering upward from the base; cystidia 12–30×6–18 μ, largest when

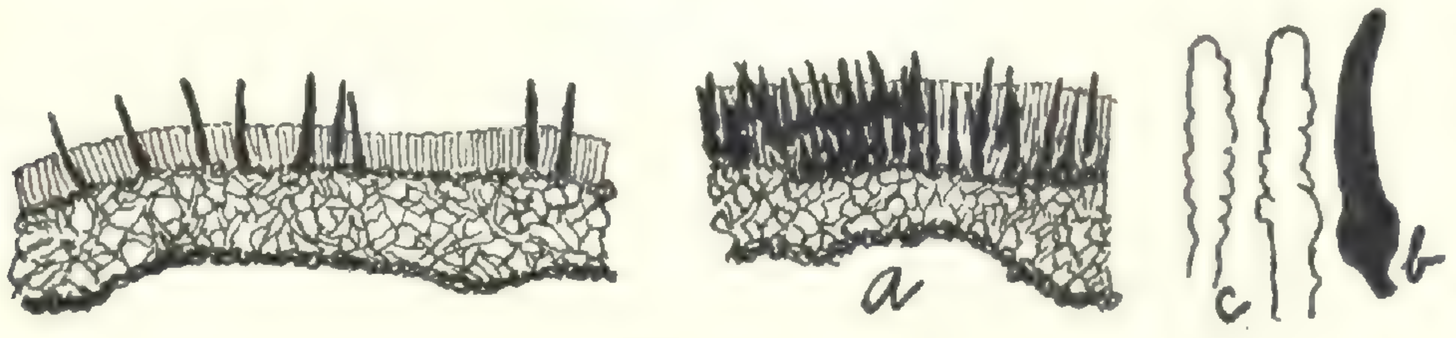


Fig. 23
H. fulva.
Section on left, × 68, from type; section *a*, × 68, seta, *b*, and cystidia, *c*, × 375, from Langlois, aj.

seated on the dark, subhymenial zone; spores borne 4 to a basidium, hyaline, even, 4½–5×2½–3 μ.

Fructifications 1×1–1½ cm., becoming laterally confluent for 7 cm. or more.

On rotting fallen limbs of frondose species. In Louisiana and Jamaica—at 4500–5200 ft. altitude in the latter. December.

H. fulva may be recognized among resupinate species by its fulvous color, not cracking, presence of an intermediate layer bordered on each side by a dark zone, with that on the under side seated directly on the substratum, and by the cystidia.

Specimens examined:

Louisiana: St. Martinville, *A. B. Langlois, aj,* and a specimen comm. by Lloyd Herb., 2422 in part.

Jamaica: Cinchona, *W. A. & Edna L. Murrill, 645,* type, comm. by N. Y. Bot. Gard. Herb.; Blue Hole, *W. A. Murrill, 182½,* comm. by N. Y. Bot. Gard. Herb.

28. H. pinnatifida Burt, n. sp.

Type: in Lloyd Herb. and Burt Herb.

Fructifications resupinate, effused, adnate, scattered, sometimes confluent, somewhat orbicular, drying between Verona-brown and cinnamon-drab, slightly glaucous, the margin antique brown, narrow, rather thick, somewhat velvety; in structure 120–240 μ thick, composed of a setigerous layer 40–80 μ broad and of a loosely interwoven intermediate layer which is

bordered on each side by a narrow, dense, dark zone; hyphae 3–3½ μ in diameter, colored, thick-walled; setae 40–70×6–7 μ, emerging up to 30 μ, tapering from the base, abundant but not crowded; colored paraphyses 1–2 μ in diameter, with pinnatifid tips, are conspicuous in the hymenium; spores hyaline, even, flattened on one side, 4–5×1½ μ, borne 4 to a basidium as seen in preparations of sections.

Fig. 24
H. pinnatifida.
Section, *a*, × 68; paraphyses, *p*, × 640.
See *pl. 17, f. 12.*

Fructifications about 1–3 cm. in diameter.

On bark of fallen frondose limbs. Georgia to Louisiana, in Mexico, Cuba, and Jamaica. August to April. Apparently common.

H. pinnatifida has some resemblance to resupinate *H. rubiginosa,* but the setae of the former are less conspicuous with the aid of a lens; the presence of colored paraphyses with pinnatifid tips distinguishes *H. pinnatifida* from all other nonstratose species.

Specimens examined:

Exsiccati: Ell. & Ev., N. Am. Fungi, 1713, under the name *Hymenochaete insularis;* Ravenel, Fungi Am., 122, under the name *Hymenochaete rubiginosa.*

Georgia: Atlanta, *E. Bartholomew, 5675* (in Mo. Bot. Gard. Herb., 44260).

Florida: *G. C. Fisher* (in Lloyd Herb., 08238); *W. W. Calkins, 82, 93* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55489, 55490), and in Ell. & Ev., N. Am. Fungi, 1713; Gainesville, *H. W. Ravenel,* in Ravenel, Fungi Am., 122; Jacksonville, *W. W. Calkins* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb.); New Smyrna, *C. G. Lloyd, 2139,* type, and *2140.*

Alabama: Auburn, *F. S. Earle, 114* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55492).

Mississippi: Jackson, *E. Bartholomew, 5798* (in Mo. Bot. Gard. Herb., 44268).

Louisiana: Abita Springs, *A. B. Langlois, 2647 to Burt;* Bogalusa, *C. J. Humphrey, 5491;* St. Martinville, *A. B. Langlois, 1621, cb, cd, D,* and a specimen from Lloyd Herb., 2422 in part; definite locality not stated, *A. B. Langlois, 136* (in U. S. Dept. Agr. Herb., in Farlow Herb., and in Mo. Bot. Gard. Herb., 44047).

Mexico: *Botteri, 31* (in Curtis Herb., under the name *Hymenochaete rubiginosa*).

Cuba: Managua, *Earle & Murrill, 6, 31,* comm. by N. Y. Bot. Gard. Herb.

Jamaica: Mandeville, *A. E. Wight,* comm. by W. G. Farlow.

29. **H. multisetae** Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and Humphrey Herb.

Fructifications resupinate, effused, adnate, thin, cinnamon-brown to Prout's brown, finally somewhat cracked, the margin determinate; in structure 35–100 μ thick, lacking an intermediate layer, with the setigerous layer dense and opaque; setae very abundant and crowded, small, 27–45×4½–5 μ, emerging up to 30 μ, starting from all parts of the setigerous layer, tapering upward; spores hyaline, even, 3–4×1–2 μ, but few found.

Fig. 25

H. multisetae. Section × 68. From type.

Fructifications 2–10×1–2 cm., sometimes encircling small limbs.

On fallen hardwood limbs in wet wooded region. Cuba and Jamaica. December and January.

H. multisetae belongs in the same group of species as *H. opaca,* which it resembles in aspect. It may be distinguished from the latter by its thinner fructifications and smaller setae.

Specimens examined:

Cuba: Ceballos, *C. J. Humphrey, 2808,* type (in Mo. Bot. Gard. Herb., 1786).

Jamaica: Chester Vale, *W. A. & Edna L. Murrill, 325, 346,* comm. by N. Y. Bot. Gard. Herb.; Moneague, *W. A. Murrill, 1186,* comm. by N. Y. Bot. Gard. Herb.; Troy and Tyre,

W. A. Murrill & W. Harris, 926, comm. by N. Y. Bot. Gard. Herb.

30. **H. anomala** Burt, n. sp.

Type: in Burt Herb. and N. Y. Bot. Gard. Herb.

Fructification resupinate, adnate, thin, vinaceous-buff, cracked, the margin determinate; in structure 75–125 μ thick, lacking a hyphal layer, composed of scattered setae, cystidia, suberect, colorless, incrusted hyphae, and crystalline matter; setae 20–50×4½ μ, emerging up to 20 μ but usually not emerging, flexuous, tapering upward, starting from all parts of the setigerous layer; cystidia colorless, incrusted, 16–20×6 μ, not emergent; spores hyaline, even, 4×2½ μ.

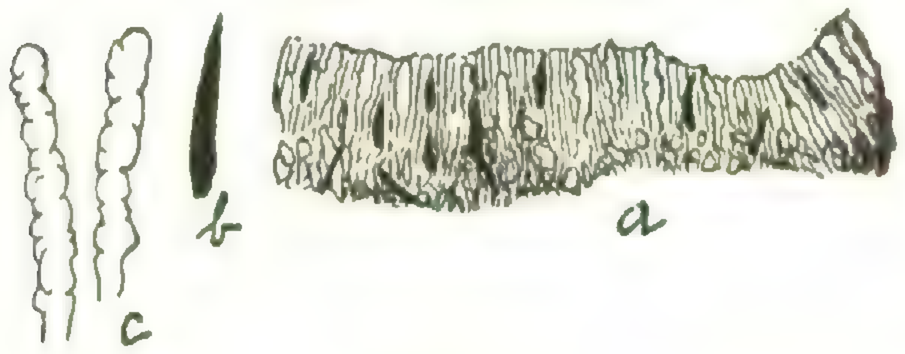


Fig. 26
H. anomala.
Section, *a*, × 120; seta, *b*, and cystidia, *c*, × 375. From type.

Fructification 2½ cm. ×5 mm., broken off at one end.

On prostrate decorticated limbs in dry thickets. Cuba. March. Rare.

H. anomala is noteworthy by its pale color, small fructification, setae only rarely protruding, and incrusted hyphae and cystidia. It differs from *H. cervina* in paler color outside and within, and in having cystidia.

Specimens examined:

Cuba: Managua, *Earle & Murrill, 36*, type, comm. by N. Y. Bot. Gard. Herb.

31. **H. corrugata** (Fr.) Léveillé, Ann. Sci. Nat. Bot. III. **5** : 152. 1846; Cooke, Grevillea **8** : 147. 1880; Sacc. Syll. Fung. **6** : 595. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 110. 1890.

Thelephora corrugata Fries, Obs. Myc. **1** : 154. 1815; Elenchus Fung. **1** : 224. 1828; Persoon, Myc. Eur. **1** : 134. 1822.— *Corticium corrugatum* Fries, Epicr. 565. 1838; Hym. Eur. 656. 1874. — *Hymenochaete insularis* Berkeley, Grevillea **1** : 165. 1873; Cooke, Grevillea **8** : 148. 1880; Sacc. Syll. Fung. **6** : 598. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 107. 1890.

Type: authentic specimen from Fries reported in Kew Herb. by Massee, *loc. cit.*

Fructifications resupinate, widely effused, closely adnate, cracked into small 4–6-sided areas, sometimes grumous, drying from cinnamon-brown to bister and Rood's brown and sometimes weathered to mouse-gray, the margin thinning out and sometimes paler; in structure 150–500 μ thick, composed of densely interwoven hyphae 3 μ in diameter, colored like the fructification, and of very numerous setae 60–70×8–12 μ, emerging up to 50 μ, somewhat cylindric below, tapering above, distributed throughout the fructification; spores white in collection on slide, even, allantoid, $4\frac{1}{2}$–7×$1\frac{1}{2}$–2 μ.

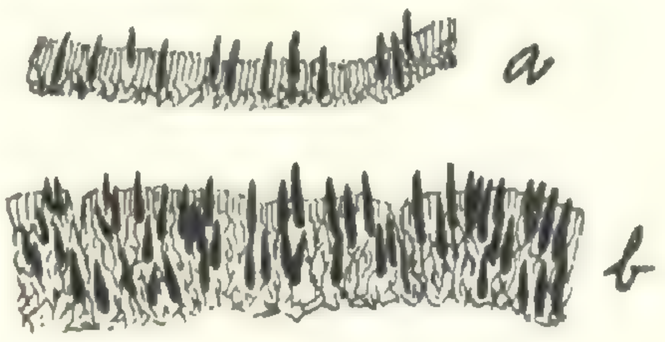


Fig. 27
H. corrugata.
Section of young fructification, *a*, and of older fructification, *b*, × 68.

Very variable in size, ranging from $2\frac{1}{2}$×1 cm. to 20×7 cm., sometimes much larger.

Very common on dead fallen limbs and trunks of frondose species, such as beech, maple, birch, and alder, rarely on coniferous wood. Canada to Texas and westward to Ohio and Kentucky, and in Jamaica. July to April.

The distinguishing characters of *H. corrugata* are its closely adnate fructification, which cracks into small, polygonal areas about 1–3 to a mm. and sometimes scales off, distribution of the rather stout setae throughout the whole very dense fructification from substratum to hymenium, and white, allantoid spores about $4\frac{1}{2}$–7×$1\frac{1}{2}$–2 μ. American collections of *H. corrugata* have a broader range in color than the European collections cited below. *H. insularis* Berk. is based upon a specimen Rood's brown in color, with whitish margin, orbicular form, and thickness of 160 μ. I have tried to regard *H. insularis* as a distinct species but it intergrades too completely in all its characters with typical *H. corrugata*. *H. episphaeria* (Schw.) is very near *H. corrugata* but is less cracked, extremely thin, and has most of its setae starting conspicuously on a dark delimiting zone next to the substratum.

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 4425, 4931; Berkeley, Brit. Fungi, 249, 298; Ellis, N. Am. Fungi, 14; Ell. & Ev., Fungi Col., 8; Krieger, Fungi Sax., 717, 1422, the latter under the name *Hymenochaete cinnamomea;* Krypt. Exs. Vind., 714; Ravenel, Fungi Am., 123, under the name *Hymenochaete crocata,* 124; Fungi Car. **5** : 26; Shear, N. Y. Fungi, 53; de Thümen, Myc. Univ., 9.

England: Berkeley, Brit. Fungi, 249, 298.

France: (in Lloyd Herb., 3346).

Germany: Saxony, *W. Krieger,* in Krieger, Fungi Sax., 717, 1422.

Austria-Hungary: Rosenau, *P. Strasser,* Krypt. Exs. Vind., 714.

Canada: *J. Macoun, 17, 19, 25;* Lower St. Lawrence Valley, *J. Macoun, 63.*

Ontario: Casselman, *J. Macoun, 362, 365;* London, *J. Dearness,* in Bartholomew, Fungi Col., 4425, and (in Lloyd Herb., 12001); Temagami, *C. G. Lloyd,* 07564 (in Lloyd Herb.).

Quebec: Hull, *J. Macoun, 242.*

Maine: Costigan, *W. A. Murrill, 1761* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55459); Orono, *F. L. Harvey,* comm. by P. L. Ricker, 1, 2.

New Hampshire: *P. Wilson* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55471); Chocorua, *W. G. Farlow.*

Vermont: Middlebury, *E. A. Burt,* two collections; Smugglers' Notch, *E. A. Burt;* Ripton, *E. A. Burt.*

Massachusetts: Magnolia, *W. G. Farlow,* two collections; Sharon, *W. G. Farlow* (in Mo. Bot. Gard. Herb., 6960), *A. P. D. Piguet,* two collections, comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 44046, 55228); Wellesley, *L. W. Riddle, 15.*

New York: Adirondack Mts., *C. H. Peck, T 27* (in N. Y. State Mus. Herb., and in Mo. Bot. Gard. Herb., 54650); Albany, *C. G. Lloyd, 07179* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55482); Alcove, *C. L. Shear, 1003,* and in Shear, N. Y. Fungi, 53; Catskill Mts., *C. H. Peck, T 11* (in N. Y. State Mus. Herb., and in Mo. Bot. Gard. Herb., 54578); East Galway, *E. A. Burt;* Freeville, *G. F. Atkinson, 3279;*

Fort Ann, *S. H. Burnham, 39* (in Mo. Bot. Gard. Herb., 54423); Hudson Falls, *S. H. Burnham, 30* (in Mo. Bot. Gard. Herb., 54482); Ithaca, *G. F. Atkinson, 2815;* Karner, *H. D. House* (in N. Y. State Mus. Herb., and in Mo. Bot. Gard. Herb., 55196); Lake Placid, *W. A. & Edna L. Murrill, 152* (in N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55001); North Greenbush, *H. D. House,* two collections (in N. Y. State Mus. Herb., and in Mo. Bot. Gard. Herb., 54385/6); Orient, *R. Latham, 154* (in Mo. Bot. Gard. Herb., 44229).

New Jersey: Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 14, in Ell. & Ev., Fungi Col., 8, and in de Thümen, Myc. Univ., 9.

Pennsylvania: Charter Oak, *L. O. Overholts, 3773* (in Mo. Bot. Gard. Herb., 54991); Trexlertown, *W. Herbst, 79.*

Maryland: Takoma Park, *C. L. Shear, 1161.*

North Carolina: *M. A. Curtis, 4456,* type of *H. insularis* (in Kew Herb. and in Curtis Herb.).

South Carolina: Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 123, 124.

Florida: New Smyrna, *C. G. Lloyd, 2120.*

Alabama: *Peters,* in Ravenel, Fungi Car. **5** : 26; Montgomery, *R. P. Burke, 53, 63* (in Mo. Bot. Gard. Herb., 16746, 18222).

Mississippi: Jackson, *E. Bartholomew, 5780* (in Mo. Bot. Gard. Herb., 9188), and in Bartholomew, Fungi Col., 4931.

Louisiana: St. Martinville, *A. B. Langlois, cc,* and *an unnumbered collection.*

Texas: Houston, *H. W. Ravenel, 261.*

West Virginia: Eglon, *C. G. Lloyd, 1411* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55470); Paw Paw, *C. L. Shear, 1178.*

Michigan: Isle Royal, *Allen & Shuntz, 16,* comm. by Univ. of Wisconsin Herb.

Ohio: Cincinnati, *A. P. Morgan,* comm. by Lloyd Herb., 2593; College Hill, *Aiken,* comm. by Lloyd Herb., 2328.

Kentucky: Crittenden, *C. G. Lloyd, N;* Harlan, *C. H. Kauffman, 74* (in Mo. Bot. Gard. Herb., 21533).

Jamaica: Morce's Gap, *W. A. & Edna L. Murrill, 732,* comm. by N. Y. Bot. Gard. Herb.

32. H. episphaeria (Schw.) Massee, Linn. Soc. Bot. Jour. **27** : 111. 1890; Cooke, Grevillea **20** : 11. 1891; Sacc. Syll. Fung. **11** : 123. 1895.

Thelephora episphaeria Schweinitz in Fries, Elenchus Fung. **1** : 225, 1828; Am. Phil. Soc. Trans. N. S. **4** : 169. 1832.

Type: in Herb. Schweinitz, Kew Herb., and Curtis Herb.

Fructification resupinate, effused, closely adnate, conforming to the irregularities of the substratum, drying buckthorn-brown to tawny olive; in structure up to 90 μ thick, with hyphae rigid, interwoven, 2–2½ μ in diameter, giving their color to the fructification; setae 60–90×9–12 μ, emerging up to 15 μ, cylindric, obtuse, starting directly from the dark, opaque, delimiting zone next to the substratum, as differentiated in permanent preparations which were treated with KHO solution and stained with eosin; no spores found in type, but hyaline, even, allantoid, 4–5×1½–2 μ in collections referred here.

Fig. 28
H. episphaeria.
Section × 68. From type.

Fructifications 1–2 cm. broad, 2–5 cm. long.

Under side of dead frondose limbs—type on *Alnus* and *Diatrype stigma*. Vermont to Pennsylvania and Illinois.

H. episphaeria resembles *H. arida* and *H. cinnamomea* in aspect, but is thinner, lacks a hyphal layer, and has its setae starting from the substratum, or very near it, and extending up through the hymenium.

Specimens examined:

Vermont: Middlebury, *C. G. Lloyd, 07221* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55558).

Massachusetts: Weston, *A. B. Seymour, T 19* (in Mo. Bot. Gard. Herb., 18358).

New York: Albany, *C. G. Lloyd, 07120* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55481).

Pennsylvania: Bethlehem, *Schweinitz,* type (in Herb. Schweinitz, in Kew Herb., and in Curtis Herb.); Trexlertown, *W. Herbst,* comm. by Lloyd Herb., 3612.

Ohio: Cincinnati, *A. P. & L. V. Morgan,* under the name *H. insularis,* comm. by U. S. Dept. Agr. Herb.

Illinois: River Forest, *E. T. & S. A. Harper, 742.*

33. H. cervina Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 334. 1868; Cooke, Grevillea **8**: 147. 1880; Sacc. Syll. Fung. **6**: 596. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 114. 1890.

Type: in Kew Herb. and Curtis Herb.

Fructification resupinate, effused, adnate, very thin, usually cracked, drying Dresden-brown, the margin thinning out; in structure 80–200 μ thick, composed of densely interwoven, suberect hyphae, of crystalline masses, and of setae; hyphae $2\frac{1}{2}$–3 μ in diameter, giving their color to the fructification; crystalline masses 12–15 μ in diameter; setae distributed in all parts of the section and some starting from the substratum, 60–90$\times$ 10–12 μ, emerging up to 40 μ, tapering from the base to a sharp apex; spores hyaline, even, 7–9$\times 3\frac{1}{2}$ μ.

Fig. 29
H. cervina.
Section, *a*, × 68; seta, *b*, cystidia, *c*, and spores, *s*, × 640. From type.

Fructifications 5 cm. or more long, about 1–2 cm. broad.

On dead limbs and decorticated wood. Illinois, Louisiana, and Cuba.

By reason of its thin fructification, few hyphae, and abundant setae starting from substratum, *H. cervina* is near *H. episphaeria* in structure and general aspect, but may be distinguished from this species by larger spores and by the presence of cystidia which finally become crystalline masses. Berkeley's comment that specimens of *H. cervina* resemble *Hymenochaete Curtisii* is misleading and probably due to his having referred to *H. cervina* a collection of *Stereum umbrinum*, the Curtis Herb., 2308.

Specimens examined:

Louisiana: *A. B. Langlois, 267*, comm. by U. S. Dept. Agr. Herb.

Cuba: *C. Wright, 213*, type (in Kew Herb. and in Curtis

Herb.); Alto Cedro, *Underwood & Earle, 1527,* comm. by N. Y. Bot. Gard. Herb.

34. H. opaca Burt, n. sp.

Type: in Burt Herb. and N. Y. Bot. Gard. Herb.

Fructifications resupinate, effused, adnate, when young slightly velvety, very thin, and between bister and Vandyke-brown, finally becoming glabrous, somewhat thicker, Vandyke-brown and cracked, the margin thinning out; in structure 200–300 μ thick, lacking an intermediate layer, with the setigerous layer very dense and opaque and composed of suberect, interwoven, dark hyphae, and of setae; setae 50–90×8–10 μ, emerging up to 60 μ, starting from all parts of the setigerous layer; spores hyaline, even, $3\frac{1}{2}$–5×$1\frac{1}{2}$–2 μ.

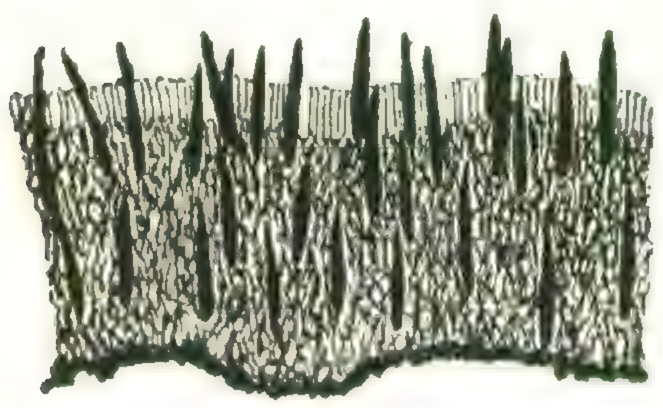


Fig. 30
H. opaca.
Section × 68. From type.

Fructifications 3–5×1–2 cm.

On bark of dead frondose limbs. Wet, wooded region, 2000–4000 ft. altitude. Jamaica. December and January.

H. opaca belongs in the group with *H. corrugata* and *H. tenuis,* from both of which it differs by its velvety surface when young, different color, darker hyphae, and denser and more opaque structure in sectional preparations.

Specimens examined:

Jamaica: Chester Vale, *W. A. & Edna L. Murrill, 297,* comm. by N. Y. Bot. Gard. Herb.; Cinchona, *W. A. & Edna L. Murrill, 538,* type, comm. by N. Y. Bot. Gard. Herb.; Troy and Tyre, *W. A. Murrill & W. Harris, 923, 937,* comm. by N. Y. Bot. Gard. Herb.

35. H. tenuis Peck, N. Y. State Mus. Rept. **40** : 57. 1887; Sacc. Syll. Fung. **6** : 599. 1888; Massee, Linn. Soc. Bot. Jour. **27** : 109. 1890.

Type: in N. Y. State Mus. Herb.

Fructifications resupinate, effused, becoming confluent, very thin, adnate, somewhat cracked, velvety, drying from raw umber to mummy-brown, the margin thinning out, indeter-

minate; in structure 30–75 μ thick, composed of a setigerous layer of densely interwoven hyphae $1\frac{1}{2}$ μ in diameter and of very numerous setae uniformly distributed from substratum to hymenium, 36–45×5–7 μ, protruding up to 30 μ, tapering upward, and terminating in slender, somewhat curved, very sharp tips; spores in spore collection white, even, flattened on one side, $4\frac{1}{2}$–$5\frac{1}{2}$×2–$2\frac{1}{2}$ μ.

Fig. 31
H. tenuis.
Section × 68. From type.

Fructifications $\frac{1}{2}$–$1\frac{1}{2}$×$\frac{1}{2}$ cm., finally confluent over areas up to 7×2–$2\frac{1}{2}$ cm.

On bark and decorticated wood of fallen limbs of *Thuja, Tsuga,* and *Sabal.* Vermont to Florida and in British Columbia. August to June. Rare.

H. tenuis belongs in the group of species with *H. corrugata* and *H. episphaeria,* from which it differs by occurrence on coniferous substratum, raw umber color, and smaller setae and the spores. The cracking of the fructification tends toward rectangular areas, as in *H. spreta,* rather than to 5- or 6-sided polygons, characteristic of *H. corrugata.*

Specimens examined:

Vermont: Ripton, *E. A. Burt.*

New York: Altamont, *E. A. Burt;* Adirondack Mts., *C. H. Peck,* type (in N. Y. State Mus. Herb.).

Pennsylvania: Bellefonte, *L. O. Overholts, 3730* (in Mo. Bot. Gard. Herb., 55095).

Florida: Green Cove Springs, *Dr. Martin* (in Ellis Coll. of N. Y. Bot. Gard. Herb., and in Mo. Bot. Gard. Herb., 55004).

British Columbia: Kootenai Mts., near Salmo, *J. R. Weir, 499* (in Mo. Bot. Gard. Herb., 3916).

36. H. fuliginosa (Pers.) Bresadola,[1] Ann. Myc. **1**: 93. 1903.

Thelephora fuliginosa Persoon, Myc. Eur. **1**: 145. 1822.—*Stereum fuliginosum* (Pers.) Fries, Epicr. 554. 1838; Hym.

[1] Bresadola states, *loc. cit.,* that *H. fuliginosa* as understood by him is not *H. fuliginosa* (Pers.) Lév., although both give the same synonymy with the name. Léveillé's combination has priority if both authors refer to the same species and it precludes Bresadola's later use of this name for a different species: hence, if, as Bresadola states, *H. fuliginosa* sensu Léveillé is distinct from *H. fuliginosa* sensu Bresadola, then *Hymenochaete fusca* Karsten is the name which should stand instead of the combination by Bresadola.

Eur. 645. 1874.—*Hymenochaetella fusca* Karsten, Hedwigia **35** : 174. 1896.— *Hymenochaete fusca* Karsten in Sacc. Syll. Fung. **14** : 218. 1900.

Fructifications resupinate, broadly effused, adnate, thin, not cracked, somewhat colliculose, bister to warm sepia, conspicuously setulose under a lens, the margin determinate; in structure with setigerous layer 150–200 μ thick, sessile upon the substratum; setae abundant, 60–75×8–9 μ, emerging up to 45 μ, starting from all parts of the setigerous layer; spores of spore collection white, even, 4×2 μ.

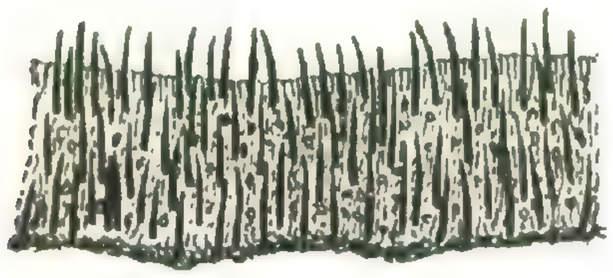


Fig. 32
H. fuliginosa.
Section ×68. From Bresadola. See *pl. 17, f. 10.*

Covering areas up to 15×5 cm.

On decorticated, rotting wood of frondose species. Vermont, Maryland, Ohio, Kentucky, and in Cuba. June to October. Local.

H. fuliginosa has the aspect of a resupinate *H. rubiginosa,* but is not separable and lacks the conspicuous ochraceous-tawny margin of the latter; when sections are viewed with the microscope they show a setigerous layer like that of *H. rubiginosa* but differing by having this setigerous layer seated directly upon the substratum instead of upon an intermediate layer. The structure in section places *H. fuliginosa* in the group of species with *H. corrugata;* it is distinguished from the latter by not cracking, by colliculose surface, and by color. American specimens agree well with that received from Bresadola, whom I have followed as to name for the present.

Specimens examined:

Sweden: authentic specimen from Karsten of *Hymenochaete fusca,* comm. by J. Bresadola.

Austria-Hungary: Hungary, *Kmet,* det. and comm. by J. Bresadola.

Vermont: Middlebury, *E. A. Burt,* three collections, and *C. G. Lloyd, 10693* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55555).

Maryland: Takoma Park, *C. L. Shear, 1157.*

Ohio: Cincinnati, *A. P. Morgan,* comm. by Lloyd Herb., 2642; locality not stated, *C. G. Lloyd, 3579.*

Kentucky: Crittenden, *C. G. Lloyd, 1414* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55556).

Cuba: *C. G. Lloyd, 435* (in Lloyd Herb., and in Mo. Bot. Gard. Herb., 55156).

SPECIES IMPERFECTLY KNOWN

37. Hymenochaete pallida Cooke & Massee, Linn. Soc. Bot. Jour. **27** : 97. 1890; Sacc. Syll. Fung. **9** : 227. 1891.

Type: in Kew Herb.

"Cartilagineo-coriacea; pileo reniformi v. subflabellato, applanato, spongioso-velutino, pallido, concentrice sulcato-zonato, margine sublobato, acuto; hymenio lineato-rugoso, velutino, umbrino, subrutilante; setis prominulis, subclavatis, 40–50×5 μ; sporae ellipsoideae, 6×3–4 μ. (Type in Herb. Kew.)

"Mexico.

"Pilei thin, 1–2 in. across, densely velvety, the pile arranged in a porous, sponge-like manner, pallid, when old almost white." —Original description.

I did not find the type of *H. pallida* in Kew Herbarium and can make no addition to the above description.

EXCLUDED SPECIES

Hymenochaete abnormis Peck, **H. fimbriata** Ell. & Ev., and **H. rugispora** Ell. & Ev. have colored paraphyses rather than cystidia and will receive consideration in *Stereum.*

Hymenochaete crassa (Lév.) Berk. is *Stereum umbrinum* or very near it.

Hymenochaete frustulosa Berk. & Curtis is *Septobasidium frustulosum.*

Hymenochaete multispinulosa Peck is *Stereum umbrinum.*

Hymenochaete musicola Berk. & Curtis is an *Asterostroma.*

Hymenochaete paupercula Berk. & Curtis is a *Peniophora.*

Hymenochaete purpurea Cooke & Morgan is *Stereum umbrinum.*

Hymenochaete setosa Berk. & Curtis is a *Hyphomycete.*

Hymenochaete siparia Berk. & Curtis is a *Septobasidium* in poor condition.

Hymenochaete tomentosa Berk. & Curtis is a *Hyphomycete.*

(To be continued.)

EXPLANATION OF PLATE

PLATE 16

The figures of this plate have been reproduced natural size from dried herbarium specimens.

Fig. 1. *Hymenochaete damaecornis.* Figure on right, from specimen collected in Jamaica by L. M. Underwood, 1399; two on left, from collection in Cuba by J. A. Shafer, 3326.

Fig. 2. *H. formosa* stage. From collection in British Honduras by M. E. Peck.

Fig. 3. *H. aspera.* Upper figure, upper surface of reflexed portion of specimen collected in Cuba by F. S. Earle, 340; lower figure, hymenium of resupinate specimen collected in Cuba by Underwood and Earle, 1513.

Fig. 4. *H. badio-ferruginea.* Collected at East Galway, New York, by E. A. Burt.

Fig. 5. *H. Berkeleyana.* Upper figure, a rosette-like cluster viewed from above, collected in Jamaica by W. A. and E. L. Murrill, 371; lower figure, hymenium of a single pileus.

Fig. 6. *H. borealis.* Upper figure, a cluster of imbricated fructifications from the type collected at Abby Pond, Ripton, Vermont, by E. A. Burt; lower figure, hymenium of a single pileus.

Fig. 7. *H. corticolor.* Reflexed specimens collected at Gainesville, Florida, by N. L. T. Nelson.

BURT—THELEPHORACEAE OF NORTH AMERICA

1. HYMENOCHAETE DAMAECORNIS.—2. H. FORMOSA STAGE.—3. H. ASPERA.—4. H. BADIO-FERRUGINEA.—5. H. BERKELEYANA.—6. H. BOREALIS.—7. H. CORTICOLOR.

EXPLANATION OF PLATE

PLATE 17

The figures of this plate have been reproduced natural size from dried herbarium specimens.

Fig. 8. *Hymenochaete cubensis.* Figure on left, upper side of pileus, and figure on right, hymenium of two small pilei, from collection in Cuba by Underwood and Earle, 1565.

Fig. 9. *H. Curtisii.* Reflexed specimens on bark collected near St. Louis, Missouri, by L. O. Overholts; the lower figure shows upper surface of the narrowly reflexed part.

Fig. 10. *H. fuliginosa.* Collected at Middlebury, Vermont, by E. A. Burt.

Fig. 11. *H. lutco-badia.* Upper figure, upper surface, and lower figure, hymenium of specimen from type distribution in Weigelt Exs., 1827, collected in Dutch Guiana.

Fig. 12. *H. pinnatifida.* From collection at New Smyrna, Florida, by C. G. Lloyd, 2140.

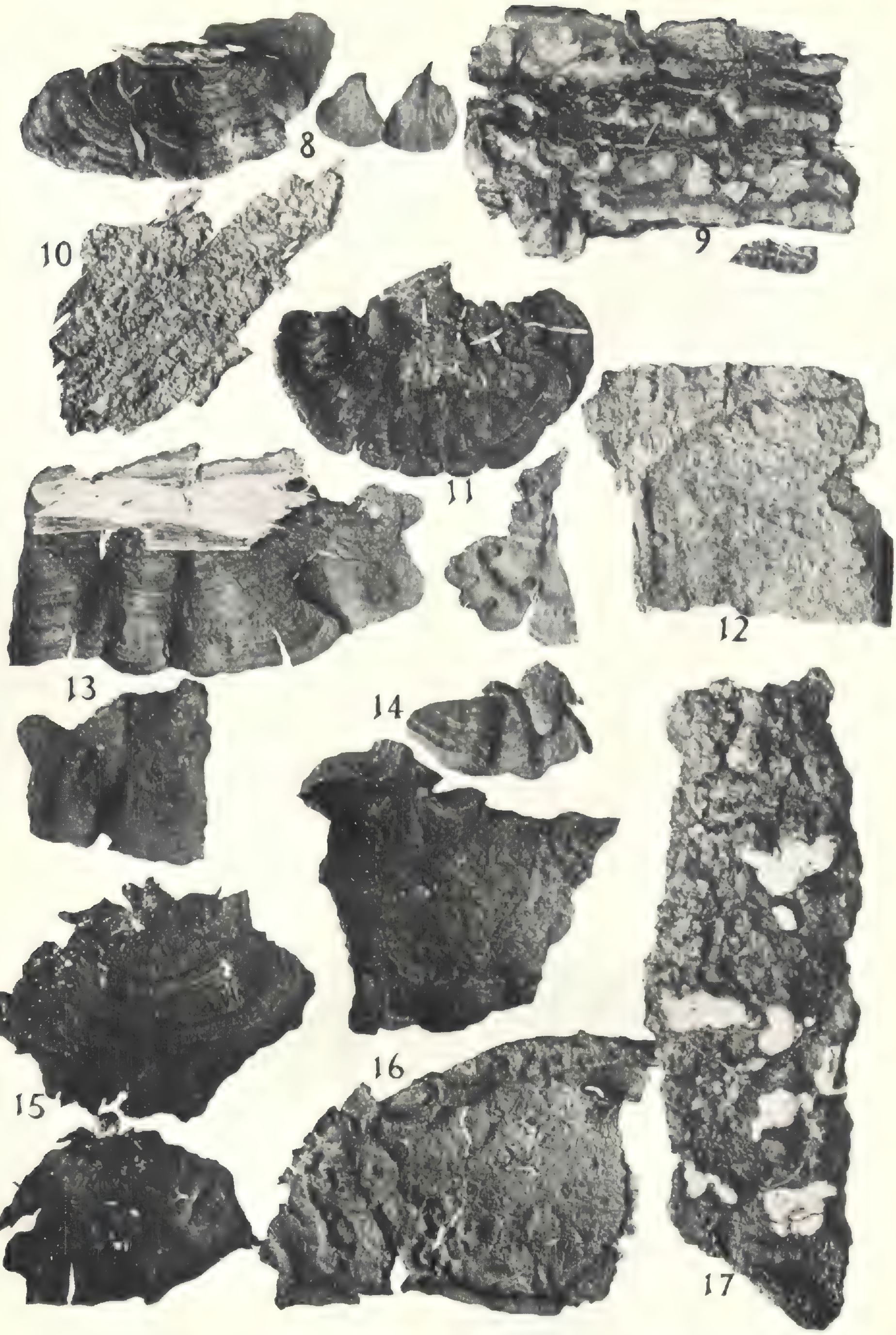
Fig. 13. *H. reflexa.* Upper figure, upper surface, and lower figure, hymenium of type collected in Jamaica by W. A. Murrill and W. Harris, 989.

Fig. 14. *H. rubiginosa.* Collected at Lake Dunmore, Vermont, by E. A. Burt.

Fig. 15. *H. Sallei.* Upper figure, upper surface, and lower figure, hymenium of specimen collected in Florida by C. G. Lloyd, 2071.

Fig. 16. *H. tabacina.* Collected at North Ferrisburg, Vermont, by E. A. Burt. The cross lines of half-tone reproduction render somewhat indistinct the systems of cracks of the hymenium which were hoped to be shown.

Fig. 17. *H. ungulata.* From the type, collected at Jalapa, Mexico, by W. A. and E. L. Murrill, 176.



BURT—THELEPHORACEAE OF NORTH AMERICA

8. HYMENOCHAETE CUBENSIS.—9. H. CURTISII.—10. H. FULIGINOSA.—11. H. LUTEO-BADIA.—12. H. PINNATIFIDA.—13. H. REFLEXA.—14. H. RUBIGINOSA.—15. H. SALLEI.—16. H. TABACINA.—17. H. UNGULATA.

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